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PAPERS.

JANUARY.

The Inversion of Sugar by Salts. By L. Kahlenberg, D. J. Davis, and R. E. Fowler 1

Sodium Aluminate as a Means for the Removal of Lime and Suspended Matter from Water for Use in Boilers. By Charles F. Mabery and Edwin B. Baltzley 23

The Heat of Bromination Test for Oils. By Augustus H. Gill and Israel Hatch, Jr 27

The Analytical Constants of American Linseed Oil. By Augustus H. Gill and Augustus C. Lamb 29

On a Balance for Use in Courses in Elementary Chemistry. By C. E. Linebarger 31

The Determination of Potash as Perchlorate. By F. S. Shiver . 33

Improved Apparatus. By J. L. Sammis 42

Glycollic Acid: One of the Acids of Sugar-cane. By Edmund C. Shorey 45

A New Apparatus for the Determination of Volume. By Chas. F. McKenna 50

t a Factor in Sugar Production. By H. A. Weber . . . 53

ercial Iron Silicides with a High Percentage of Silicon: Their perties, Manufacture, and Uses. By G. deChalmot . . 59

of Quinoline. By P. F. Trowbridge 66

Review: Third International Congress of Applied Chemistry . . 73

Note: A Convenient Method for Maintaining Reduction of Ferrous Solutions 103

New Books: Elements of General Chemistry with Experiments; Introduction to Chemical-technical Analysis; Commercial Organic Analysis, Vol. IV.; Manual of Determinative Mineralogy with an Introduction on Blowpipe Analysis; A Text-book of Volumetric Analysis with Special Reference to the Volumetric Processes of the Pharmacopoeia of the United States; Commercial Organic Analysis, Vol. I; Lehrbuch der anorganischen Chemie; Preliminary Report of an Investigation of Rivers and Deep Ground Waters of Ohio as Sources of Public Water Supplies 103

Books Received 114

FEBRUARY.

A New Method for the Determination of Zinc. By A. C. Langmuir . 115

Baumé's Hydrometer—American Standard. Calculated by Sidney S. Emery 119

The Determination of Arsenic in Glycerine. By A. C. Langmuir . 133

On the Isourea Ethers and Other Derivatives of Ureas. By F. B. Dains 136

8300
115
Star

140900

The Nature of Valence. By F. P. Venable 192
Sixth Annual Report of the Committee on Atomic Weights. Results Published in 1898. By F. W. Clarke 200
Note: Drown's Method of Determining Silicon 215
Books Received 216

MARCH.

The Solubility of Iodine in Dilute Potassium Iodide Solutions. By A. A. Noyes and L. J. Seidensticker 217
The Nature of Valence, II. By F. P. Venable 220
Emetine Octoiodide and the Extraction and Estimation of Alkaloids Generally. By H. M. Gordin and A. B. Prescott 231
Notes on the Rapid Determination of Tungsten in Steel. By George Auchy 239
The Absorption of Methane and Ethane by Fuming Sulphuric Acid. By R. A. Worstall 245
The Velocity of the Reaction between Silver Acetate and Sodium Formate. A Reaction of the Third Order. By Arthur A. Noyes and George T. Cottle 250
Coumarin and Vanillin, their Separation, Estimation, and Identification in Commercial Flavoring Extracts. By William H. Hess and Albert B. Prescott 256
New Method for the Preparation of Cesium. By Hugo Erdmann and A. E. Menke 259
The Oxidation of Formic Aldehyde by Hydrogen Peroxide. By J. H. Kastle and A. S. Loevenhart 262
Upon the Action of Sulphuric Acid on Thymol, III. By James H. Stebbins 276
Molecular Weights of Liquids, III. By Clarence L. Speyers . . 282
A New Filtering Medium. By Geo. Wm. Sargent and Jno. Kirk Faust 287
Silica and Insoluble Residue in Portland Cement. By P. W. Shimer 289
Analytical Research on Sod Oil. By Erastus Hopkins, D. L. Coburn, and Edw. Spiller 291
Correspondence Relating to the Berzelius Memorial Services . . 300
Note: A Method for Cleansing Burettes 302
New Books: Chemische Technologie an der Universitäten und technischen Hochschulen Deutschlands; Laboratory Work in Physiological Chemistry; Electrolysis and Electrosynthesis of Organic Compounds; Michael Faraday, His Life and Work; Text-book of Medical and Pharmaceutical Chemistry; Essentials of Materia Medica, Therapeutics, and Prescription Writing; A Manual of Chemical Analysis—Qualitative and Quantitative; An Introductory Course of Quantitative Chemical Analysis with Explanatory Notes and Stoichiometrical Problems; Inorganic Chemistry According to the Periodic Law; Commercial Organic Analysis, Vol. II, Part I 302
Books Received 315

APRIL.

Explosions Caused by Commonly Occurring Substances. By Charles E. Munroe 317
Preparation of Metallic Tellurium. By Victor Lenher . . . 347
The Assay of Nux Vomica. By Edward R. Squibb 351
Detection of Caramel in Spirits and Vinegar. By C. A. Crampton and F. D. Simons 355
A Study of the Relative Value of Lacmoid, Phenacetolin, and Erythrosine as Indicators in the Determination of the Alkalinity of Water by Hehner's Method. By Joseph W. Ellms . . . 359
Some Notes on the Estimation of Carbohydrates. By F. W. Traphagen and W. M. Cobleigh 369
The Atomic Mass of Tungsten and the Preparation of Sodium Pertungstate by Means of the Electric Current. By George Edward Thomas 373
Observations on Derivatives of Aconitic Acid. By D. C. Hanna and Edgar F. Smith 381
Action of Hypophosphorous Acid upon Molybdic Acid. By Clarence Ebaugh and Edgar F. Smith 384
On the Constitution of Barytocelestites. By C. W. Volney . . . 386
Notes: The Determination of Arsenic in Glycerine; Corrections in Baumé's Hydrometer Tables 388

MAY.

The Use of Compressed Oxygen in Elementary Organic Analysis and of Soda-lime in the Quantitative Determination of Carbon Dioxide. By Francis G. Benedict and Olin F. Tower 389
The Determination of Carbon Monoxide, Methane, and Hydrogen by Combustion. By L. M. Dennis and C. G. Hopkins . . . 398
The Surface-tensions of Aqueous Solutions of Alkaline Chlorides. By C. E. Linebarger 411
Estimation of the Lime, Potash, and Phosphoric Acid in Hawaiian Soils Probably Available for the Immediate Crop. By Walter Maxwell. 415
Tests for Boric Acid. By Victor Lenher and J. S. C. Wells . . 417
The Specific Gravity of Cesium. By A. E. Menke 420
An Apparatus to Facilitate Hydrogen Sulphide Precipitations. By Richard K. Meade 421
Action of a Hard Water on Certain Metals. By Jas. Lewis Howe and J. L. Morrison 422
Notes on the Analysis of Dynamite and Gelatine Dynamite. By F. W. Smith 425
A Modification of Pierce's Method for the Determination of Arsenic in Ores. By J. F. Bennett, Jr 431
A Simple Volumenometer. By C. E. Linebarger 435
The Solubility, in Water, of Certain Natural Silicates. By George Steiger 437
A Method of Analysis for Canned Condensed Milk. By F. S. Hyde . 439
Reviews: On Recent Progress in Photochemistry; A Review of the

Present Knowledge of Sodium Nitrate, Together with the Origin, Production, and Destruction of Nitrates in the Soil . . . 445
Notes: On a Possible Error in the Determination of Nitrogen in Nitrates Due to Impurities in Reduced Iron; On the Determination of Sulphur in Sulphites; Fuller's Earth 468
New Books: The Outlines of Industrial Chemistry; The Practical Compounding of Oils, Tallow, and Grease for Lubrication, etc.; Lighting by Acetylene; Lavas and Soils of the Hawaiian Islands; Testing Milk and Its Products 470
Books Received 475

JUNE.

Egg Albumin. By Thomas B. Osborne 477
On Some Definite Compounds of Protein-Bodies. By Thomas B. Osborne 486
The Theory of the Formation of Nickel Sulphide. By J. Livingston R. Morgan and A. H. Gotthelf 494
On the Determination of Added Water in Milk. By A. G. Woodman . 503
Determination of Calcium and Magnesium in Ashes. By J. K. Haywood 508
The Effect of Di-ionic Electrolytes on the Solubility of Tri-ionic Electrolytes with Different Ions. By Arthur A. Noyes and Edward S. Chapin 511
Measurements of "Turbidity" in Water. By W. P. Mason . . . 516
The Toxic Action of Sodium Fluoride. By Herbert B. Baldwin . . 517
The Theory of the Separation of Barium, Strontium, and Calcium from the Mixed Sulphates. By J. Livingston R. Morgan 522
Review: A Brief History of the Movement for Increasing the Accuracy and for Improving the Construction of Chemical Measuring Instruments 527
New Books: Maassanalytische Studien 550
Books Received 556
Correction 556

JULY.

Carbon Combustions in a Platinum Crucible. By P. W. Shimer . . 557
The Influence of Temperature on the Specific Rotation of Sucrose and Method of Correcting Readings of Compensating Polariscopes Therefor. By Harvey W. Wiley 568
The Determination of Carbon and Hydrogen in Organic Substances Containing Nitrogen. By O. F. Tower 596
Paraffin as an Adulterant of Oleomargarine. By Joseph F. Geisler . 605
Xanthine Bases in Sugar-cane. By Edmund C. Shorey 609
A Contribution to the Chemistry of Butter-fat. I. The Physical and Chemical Constants of Butter-fat. By C. A. Browne, Jr. . . . 612
Notes: How to Ignite a Hydrogen Jet with no Possibility of Exploding the Generator; A New Test for Cocaine 634
Books Received 635

AUGUST.

On the Optical Rotation of Pinen Hydrochloride. By J. H. Long . 637
Separations of Metallic Sulphides by Means of Hydrochloric Acid Gas. By J. Bird Moyer 642
The Incandescent Electric Lamp as a Source of Heat in Ether Extraction. By C. G. Hopkins 645
Classifications of the Carbides: Their Modes of Formation and Reactions of Decomposition. By J. A. Mathews 647
An Examination of Commercial Flour. By Henry Kraemer . . 650
Preparation of Graphitoidal Silicon. By Frederick S. Hyde . . 663
The Comparative Value of Certain Reagents for Removing Lime and Magnesia from Natural Waters for Industrial Uses. By Martin L. Griffin 665
Review: The Retort Coke Oven and the Chemistry of Its By-Products. 678
Note: The Occurrence of Vanadium, Chromium, and Titanium in Peats 706
New Books: Richter's Organic Chemistry, Vol. I; Traité d 'Analyse Chimique Quantitative par Electrolyse; Physical Chemistry for Beginners; The Elements of Physical Chemistry; The Microscopy of Drinking Water; The Spirit of Organic Chemistry; Die chemische Energie der Leben den Zellen; A History of Physics in Its Elementary Branches; Chemistry and Metallurgy Applied to Dentistry; A Treatise on Photographic Optics; Anleitung zur Darstellung chemischer Praparate 708
Erratum 718

SEPTEMBER.

The Distinction of True Extract of Vanilla from Liquid Preparations of Vanillin. By William H. Hess 719
A Simplified Reductor. By P. W. Shimer 723
On van 't Hoff's Equation and the Molecular Weights of Liquids. By C. L. Speyers 725
Hydrastine Hexaiodide, and the Assay of Hydrastis Canadensis, by Means of Standard Iodine for Hydrastine and of Standard Potassium Iodide for Berberine. By H. M. Gordin and A. B. Prescott . 732
Upon the Action of Diazo Compounds on Thymolparasulpho Acid, II. By James H. Stebbins, Jr 741
A New Volumetric Method for Magnesium. By Richard K. Meade . 746
Notes on Alkali Soil in Montana. By F. W. Traphagen and W. M. Cobleigh 753
A Chemical Study of Wheat. By G. B. Frankforter and E. P. Harding 758
The Estimation of Arsenic in Paris Green. By Thorn Smith . . 769
The Determination of Sulphur in Bitumens. By S. F. and H. E. Peckham 772
A New Method for the Direct Determination of Alumina in Presence of Iron, Manganese, Calcium, and Magnesium. By William H. Hess and E. D. Campbell 776

The Determination of Antimony in Ores. By Thomas Brown, Jr. . 780
Electrolytic Determination of Zinc in the Presence of Manganese. By Emil J. Riederer 789
The Influence of Substituents on the Electrical Conductivity of Benzoic Acid. By Alfred Tingle 792
New Books: A Digest of Metabolism Experiments in which the Balance of Income and Outgo was Determined; The Arithmetic of Chemistry 804
Books Received 805

OCTOBER.

A Contribution to the Chemistry of Butter-fat. II. The Chemical Composition of Butter-fat. By C. A. Browne, Jr 807
Halides and Perhalides of the Picolines. By Paul Murrill . . . 828
The Determination of Nickel in Nickel-Steel. By George Wm. Sargent 854
The Quantitative Estimation of Boric Acid in Tourmaline. By George W. Sargent 858
An Electrolytic Study of Benzoin and Benzil. By Joseph H. James . 889
Electrolytic Determinations and Separations. By Lily G. Kollock . 911
Action of Hydrochloric Acid Gas upon Sulphates, Selenates, Tellurates, and Phosphates. By Raymond W. Tunnell and Edgar F. Smith . 929
The Precipitation of Copper by Zinc. By John C. Shengle and Edgar F. Smith 932
The Persulphates of Rubidium, Cesium, and Thallium. By Arnott R. Foster and Edgar F. Smith 934
The Chromic Acid Test for Cocaine. By George L. Schaefer . . 936
Notes: On the Reichert Figure of Butter; Analysis of Zinc for Cadmium and Lead 938
Books Received 942
Erratum 942

NOVEMBER.

Derivatives and Atomic Mass of Palladium. By Willet Lepley Hardin 943
The Action of Sodium Methylate upon Dibromides of Propenyl-compounds and of Unsaturated Ketones. By F. J. Pond, O. P. Maxwell, and G. M. Norman 955
The Electrolytic Oxidation of Succinic Acid. By Charles H. Clarke and Edgar F. Smith 967
Notes on the Determination of Sulphur in Pig Iron. By M. J. Moore . 972
A Contribution to the Chemistry of Butter-fat. III. The Chemistry of Rancidity in Butter-fat. By C. A. Browne, Jr. 975
Some Boiling-point Curves, II. By J. K. Haywood 994
The Electrolysis of Metallic Phosphate Solutions. By Harry M. Fernberger and Edgar F. Smith 1001
Observations upon Tungsten. By Edgar F. Smith 1007
On β-Heptylamine, I. By Thomas Clarke 1027

The Amount of Humus in Soils and the Percentage of Nitrogen in the Humus, as Affected by Applications of Air-slaked Lime and Certain Other Substances. By H. J. Wheeler, C. L. Sargent, and B. L. Hartwell 1032
Note on the Color of Chlorine Solutions. By E. H. Sarles . . . 1038
Improvement in the Chemical Composition of the Corn Kernel. By Cyril G. Hopkins 1039
Note: The Determination of Chromium in Steel 1057
New Books: The Discharge of Electricity through Gases; Easy Experiments of Organic Chemistry; A Select Bibliography of Chemistry, 1492–1897; School Chemistry; A Short History of the Progress of Scientific Chemistry in Our Own Times; Examination of Water, Chemical and Bacteriological; The Liquefaction of Gases; Elementary Studies in Chemistry; The Mineral Industry, Vol. VII; The Rise and Development of the Liquefaction of Gases; Qualitative Analysis for Secondary Schools; The Elements of Blowpipe Analysis; A Treatise on the Kinetic Theory of Gases; Inorganic Chemical Preparations; The Elements of Qualitative Analysis; The Compendious Manual of Qualitative Chemical Analysis of C. W. Eliot and F. H. Storer 1060
Books Received 1073

DECEMBER.

The Nature of the Change from Violet to Green in Solutions of Chromium Salts. By W. R. Whitney 1075
The Determination of the Bromine Absorption of Oils. By Parker C. McIlhiney 1084
The Direct Determination of Available Phosphoric Acid. By F. P. Veitch 1090
Note upon the Determination of Nitrogen in Fertilizers Containing Nitrates. By F. P. Veitch 1094
Notes on Testing Soils for Application of Commercial Fertilizers. By H. A. Weber 1095
On the Universal Distribution of Titanium. By Charles Baskerville . 1099
The Relation of Physical Chemistry to Technical Chemistry. By Wilder D. Bancroft 1101
Apparatus for the Analysis of Illuminating and Fuel Gases. By Geo. E. Thomas 1108
The Determination of Graphitic Carbon in Cast and Pig Iron. By Allen P. Ford and I. M. Bregowsky 1113
Report of the Committee on Coal Analysis. William A. Noyes, W. F. Hillebrand, and C. B. Dudley 1116
Lemon Flavoring Extract and Its Substitutes. By A. S. Mitchell . 1132
On the Determination of Volatile Combustible Matter in Coke and Anthracite Coal. By Richard K. Meade and James C. Attix . 1137
Review: Some Records of Progress in Applied Chemistry . . . 1145

Notes: Chemical Detection of Vegetable Fibers; Repairing Beckmann Thermometers 1175
New Books: Indicators and Test-papers; A Course in Quantitative Chemical Analysis, Gravimetric and Volumetric 1176
Erratum 1178
Books Received 1178
Index 1179

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THE INVERSION OF SUGAR BY SALTS.

BY L. KAHLENBERG, D. J. DAVIS AND R. E. FOWLER.

Received September 20, 1898.

INTRODUCTION.

THE inversion of cane-sugar by salts has been studied by Walker and Aston[1], who determined the affinity of weak organic bases by ascertaining the extent to which their hydrochlorides are decomposed by water from the speed with which solutions of these salts invert sugar. They also measured the speed with which sugar is inverted by the nitrates of lead, cadmium, aluminum, zinc, and hydrogen. The work on the inorganic salts was conducted at 80°C., the sugar solution used being about ten per cent. The results are given in Table I, the coefficient C indicating the speed of the inversion.

TABLE. I.

Nitrates.	C.	Hydrolysis per cent. in equiv. $\frac{n}{2}$ solution.
Cadmium ($\frac{n}{2}$)	0.000154	0.014
Zinc ($\frac{n}{2}$)	0.000207	0.019
Lead ($\frac{n}{2}$)	0.001590	0.015
Aluminum ($\frac{n}{2}$)	0.007700	0.700
Hydrogen ($\frac{n}{1000}$)	0.002250	....

As the speed of inversion is proportional to the concentration of the hydrogen ions present (the latter being formed by the hydrolysis of the salt) the coefficients represent roughly the relative strengths of the respective bases. In the last column of

[1] *J. Chem. Soc.*, London, 67, 576.

the table are the percentages of hydrolysis in equivalent half-normal solutions as deduced by comparing the values of C for the salts with that of the millinormal nitric acid solution.

J. H. Long[1] made a more extensive investigation of the inversion of sugar by inorganic salts. He pointed out that salts of the heavy metals in general have the power of inverting sugar solutions, and in some cases very rapidly, especially at an elevated temperature. He also correctly indicated that the cause of the inversion by these salts is to be found in their condition of partial hydrolysis by the solvent. Long gave special prominence to the work with ferrous salts; in addition to these, however, he investigated the chlorides of manganese, cadmium, mercury, and lead, the sulphates of manganese, zinc, and aluminum (potassium alum), and the nitrate of lead. The coefficients expressing the rate of inversion were calculated and the percentages of hydrolyzed salt were deduced by comparing these coefficients with that obtained by employing a millinormal hydrochloric acid solution under like conditions. The temperature at which Long's systematic investigations were performed is 85°, and the sugar solution used was of such strength that fifty grams were contained in 250 cc.

In the investigations of Walker and Aston and also in those of Long the polariscope was used exclusively to follow the progress of the inversion. This is no doubt the simplest and most accurate method to use whenever it is applicable. It is evident, however, that the polariscope cannot be used in working with colored solutions and that the accuracy of measurement with this instrument is greatly impaired when the solutions are not perfectly clear. Long cites several instances where, after prolonged heating, the solutions became somewhat colored or turbid, making their polarization difficult.

The objects of this investigation are: (1) to find a method by means of which the speed of inversion of sugar by colored salts can be determined, and (2) to compare the basicity of the metals as ascertained by the method of sugar inversion with their so-called solution tensions, as found by the measurement of the electromotive forces of galvanic chains.

The inversion of sugar is expressed by the equation:

$$C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6.$$

[1] This Journal, 18, 120 and 693.

If the solution is not too concentrated, the change in the number of molecules of water may practically be neglected. From the equation it appears that during the process of inversion each molecule of cane-sugar is converted into two molecules. Now since the osmotic pressure exerted by a dissolved substance is proportional to the number of its molecules, it is clear that when inversion is complete the dissolved sugar will exert just double the osmotic pressure that it did in form of cane-sugar. Furthermore, by measuring the osmotic pressure from time to time during the progress of the inversion, the rate of the latter may be determined. As the methods that are known at present for the direct measurement of the osmotic pressure could not be used advantageously, it was decided to measure some physical property that is proportional to the osmotic pressure. The lowering of the freezing-point and the elevation of the boiling-point suggested themselves. Trevor and Kortright[1] have shown that by noting from time to time the boiling-point of a sugar solution to which a small quantity of acid has been added, the speed of the inversion can be determined. A few preliminary tests indicated that the boiling-point method is not well suited for studying the inversion of sugar by salts of the heavy metals, for by boiling the solutions some of these salts suffer considerable reduction. The freezing-point method was consequently chosen, although less convenient of execution. Before this method was applied in the work with colored salts it was definitely ascertained that it would yield reliable results. This was done by following the progress of the inversion of several colorless solutions by both the polariscope and cryoscopic methods.

METHOD OF EXPERIMENTATION.

The following is an outline of the method of experimentation. The desired quantities of sugar and salt were weighed out and each was dissolved in a small quantity of water, generally with the aid of heat. These solutions were then thoroughly cooled and finally mixed in a graduated flask, cold water being added to fill the latter to the mark. It was found that at room temperature the inversion takes place very slowly; nevertheless no time was lost unnecessarily in transferring the solution to test-tubes, generally eight to ten in number, which were then tightly

[1] *Ztschr. phys. Chem.*, 14, 149.

stoppered with rubber stoppers or closed by fusing the ends. These tubes were then kept at a higher temperature in a thermostat, the time of their introduction into the latter was noted, and then from time to time one was taken out and quickly immersed in a bath of melting ice to cool it rapidly and thus check the reaction. Its contents were then examined with the polariscope or freezing-point apparatus or both. A few tests showed that at o° the inversion in the solutions used was so slow that no change could be detected for hours. It was consequently not necessary to investigate each tube at once, but several could thus be collected and their contents tested in rapid succession. While this is of no particular importance in working with the polariscope, with which determinations are so easily made, it is very advantageous in employing the freezing-point method, as it admits of making the determinations more rapidly and with a greater degree of accuracy relatively. It consumes time to prepare the freezing mixture properly and to find the freezing-point of pure water on the thermometer scale. The latter operation of course must be performed each time a series of observations is made, as the reading of a Beckmann's thermometer for a fixed temperature varies from time to time, partly because changes in the barometric pressure affect the bulb, and partly because minute amounts of mercury escape from the mercury that is attached to the thread in the upper chamber to the lower part of that chamber. The mercury can often be seen in form of very fine drops condensed on the sides of the upper chamber after the thermometer has stood for a number of hours.

Crystallized cutloaf sugar of a high degree of purity was used in all the experiments. It was dried, pulverized, and thoroughly mixed. For each series of experiments 84.93 grams were weighed out and dissolved in a small amount of water in a 500 cc. flask that was carefully graduated. The cold solution containing one-fourth of a gram equivalent of the salt to be investigated was then added. The solutions were mixed and finally made up to exactly 500 cc. Thus the resulting solution was half-normal with respect to each, the sugar and the salt.[1] All the salts used were of the C. P. variety of standard makes. They were recrystallized several times to free them from any

[1] In a few cases less concentrated solutions had to be used on account of the slight solubility of the salt.

excess of acid they might contain. Thirty cc. of the solution last named were introduced into each of the test-tubes, which were twenty cm. long. These were then quickly sealed in a hot pointed flame. The liquid did not change its temperature materially during this operation. After the supply of twenty cm. test-tubes was exhausted, eighteen cm. ones were used; these could not be sealed as readily without heating the solution somewhat, so they were tightly stoppered with rubber stoppers.

The bath in which the tubes were placed is shown in Fig. 1. The cylindrical outer vessel *A* is thirty cm. high and thirty cm. in diameter. It is fitted with a similarly shaped inner vessel *B*, so that the distance between the sides of the two vessels is about four cm. and that between the bottoms eight cm. This part of the apparatus is made of tin. A spiral return condenser of glass is fitted to *A* as indicated. A bent glass tube *D* serves as a gauge to indicate the height of the liquid in *A*. *B* contains water in which the test-tubes are immersed. It has a wooden

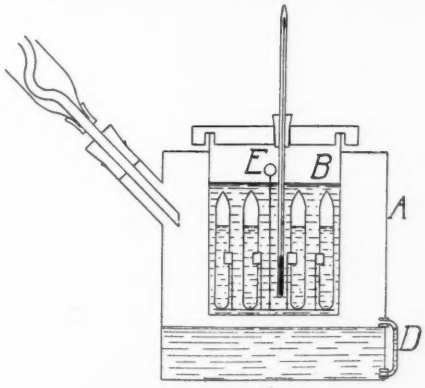

Fig. 1.

cover through which a thermometer is inserted. The test-tubes are held in position by wires as indicated. These wires are soldered on a disk of heavy tin provided further with a stout central wire *E*, by means of which all the tubes together with the supporting disk can be placed into the apparatus at the same time.

At first it was proposed to perform the experiments at about

80° C.; but a preliminary test on copper sulphate, using alcohol in the vessel *A*, showed that this temperature was too high inasmuch as partial reduction of the salt to the cuprous condition and even to metallic copper occurred. After still further tests, the temperature of boiling acetone, 55.5° C. was finally chosen.

The acetone was placed in *A* (Fig. 1), and kept boiling by a small flame. Water of the temperature of about 65° was poured into *B* to such a height that when the tubes were finally introduced they were sufficiently immersed. By introducing the cold tubes into this bath of a little higher temperature than finally desired, the temperature of the whole soon became 55.5°. This did not require more than three or four minutes. The tubes were ordinary test-tubes. They were cleaned with concentrated hydrochloric acid, washed with water, and finally thoroughly steamed according to Ostwald's[1] suggestion. A sample of the solution was always retained for making the initial determination. The time when the tubes were introduced into the bath was taken as the starting-point and placed equal to zero. This, of course, was not quite correct, as the temperature was not instantly adjusted. The error introduced was not great, however; it would show itself mainly in the first coefficient found, which would be a little too low.

The polariscope used was a triple field instrument manufactured by Schmidt & Haensch. It was of a pattern devised by Landolt.[2] All the observations were made in a twenty cm. tube at 20° C., the liquids being kept at this temperature during the time of the determination by running water of 20° C. through the jacket surrounding the observation tube.

The freezing-point apparatus was essentially of the form of that constructed by Beckmann,[3] but its dimensions were larger The tube containing the solution and the differential thermometer had no side neck; it was about twenty-two cm. long, and nearly five cm. in diameter. The thermometer and the stirrer[4] passed through the cork as usual, but the latter was further provided with another opening through which the freezing could be

[1] Hand- u. Hilfsbuch, p. 295.

[2] *Ber. d. chem. Ges.*, **28**, 3102.

[3] Compare Ostwald's Hand- u. Hilfsbuch, p. 216.

[4] The stirrer had the usual shape, but was made entirely of glass. With an apparatus of the above dimensions this works very well and is much cheaper than the usual stirrer with the heavy platinum loop.

inaugurated by "vaccinating" the slightly overcooled liquid with a bit of ice. The air jacket was made of heavy tin; it was soldered to the cover of the jar, and the whole was then heavily coated with asphaltum to prevent rusting. The jar containing the freezing-mixture was an ordinary large size gravity battery jar. A Beckmann's thermometer was used. It was graduated to hundredths and the thousandths could be judged by means of a lens. Generally thirty cc. of the solution were tested. The temperature of the bath was so regulated that it was only a few tenths of a degree lower than the freezing-point of the liquid tested.

The calculation of the coefficient C expressing the speed of the reaction was made according to the well-known formula $C = \frac{1}{t} \log_{10} \frac{A}{A-x}$, in which A represents the amount of cane-sugar present at the beginning, and x the amount inverted during the time t. In working with the polariscope, A is measured by the total change in rotation observed from the beginning to the end of the reaction, and x is measured by the change in rotation during the time t. In applying the freezing-point method, A is measured by the total increase in the lowering of the freezing-point of the solution from the beginning to the end of the reaction, and x is measured by the increase in the lowering during the time t. In thus applying these methods, it is assumed that the influence of the salt present in solution on the rotation and freezing-points respectively is constant throughout the reaction. Though the action of the salt on the cane-sugar, and the invert sugar is probably slight, some interaction does seem to take place as Long[1] has already pointed out.

A half-normal solution of cane-sugar gave as an average of four series of independent experiments a lowering of the freezing-point of 1.114°. A solution that was half-normal with respect to cane-sugar, and centinormal with respect to hydrochloric acid gave a lowering of 2.248° after complete inversion had taken place. The sugar after inversion would theoretically cause the lowering to be 2.228°, consequently the difference, 0.020°, is the lowering caused by the acid. Theoretically the hydrochloric acid ought to give the lowering 0.019°; but since in centinormal

[1] This Journal, 18, 716.

solution the dissociation is nearly complete, this figure would become 0.038°. It is clear then that the above result, 2.248°, is a little too low, theoretically considered; it was thought to be sufficient, however, to warrant adopting the figure 1.114° in future calculations as the increase of lowering of the freezing-point caused when the inversion is complete.

It is somewhat difficult at times to obtain the exact rotation of the plane of polarization of a sugar solution after complete inversion because of changes produced by prolonged heating.[1] For this reason, the calculated value found by reckoning 0.315°[2] negative rotation for every degree of initial positive rotation was used as the end-point of the reaction except when the observed value exceeded it. Thus, the most probable initial angle for the twenty cm. tube was found to be 22.60°; the end-point would consequently be 22.60° × —0.315 or —7.12°.

RESULTS.

The experimental results will now follow in detail.

TABLE II.

Hydrochloric Acid.

In 1000 cc., $\frac{1}{4}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{100}$ g. mol. HCl. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	22.62°	.....	.....
1.0	16.58	6.04	0.0983
2.0	9.92	12.70	0.1205
2.5	7.68	14.94	0.1208
3.0	5.94	16.68	0.1186
4.0	2.54	20.08	0.1215
4.5	1.42	21.20	0.1198
7.0	—2.40	25.02	0.1130
17.5	—6.90	29.52	0.1142
26.5	—7.20	29.82	.....
			0.1158

TABLE III.

Hydrochloric Acid.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{100}$ g. mol. HCl. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0.0	1.175°	.....	.....
1.0	1.393	0.218	0.0977
2.0	1.635	0.460	0.1217
2.5	1.705	0.530	0.1185
3.0	1.809	0.634	0.1296
4.0	1.912	0.737	0.1263
4.5	1.954	0.779	0.1252
7.0	2.105	0.930	0.1254
17 5	2.230	1.055	0.1028
26.5	2.247	1.072	.....
			0.1147

[1] Compare Long: This Journal, 18, 697.
[2] Compare Rayman and Sulc: *Ztschr. phys. Chem.*, 21, 488.

In Table II, —7.2° was taken as the end-point and in Table III, 2.247°, for the change that had taken place in nine hours was but 0.3° on the polariscope scale and 0.017° on that of the thermometer. Considering the experimental difficulties encountered in the work the agreement of the values of C in Table III, with those in Table II, must be considered sufficient. It has been established therefore that the freezing-point method can be successfully used to determine the rate of inversion of sugar. As the amount of hydrochloric acid present was small as compared with the amount of sugar, this was an especially favorable case in which to test the reliability of the cryoscopic method in following the progress of the reaction. Further comparisons between the two methods in which salts were used to invert the sugar will be given below.

ALUMINUM SALTS.

The aluminum salts investigated are potassium alum, aluminum sulphate and chloride. The alum solution was weaker than the usual strength on account of the low solubility of the salt in the cold.

TABLE IV.

Potassium Alum.

In 1000 cc., $\frac{1}{4}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{32}$ g. mol. $K_2Al_2(SO_4)_4$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	11.23°	....	....
1.0	10.48	0.75°	0.02260°
2.0	9.29	1.94	0.03053
4.0	8.12	3.11	0.02551
6.5	6.35	4.88	0.02675
8.0	5.54	5.69	0.02637
41.25	—2.54	13.77	0.02815
83.5	—3.16	14.39	0.02525
∞	—3.56	14.79	....
			0.02645

TABLE V.

Potassium Alum.

In 1000 cc., $\frac{1}{4}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{32}$ g. mol. $K_2Al_2(SO_4)_4$. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0.0	0.855°	....	....
1.0	0.859(?)	0.004°(?)	0.00313°(?)
2.0	0.889	0.034	0.01368
4.0	0.925	0.070	0.01458
6.5	0.980	0.125	0.01697
8.0	1.009	0.144	0.01757
41.25	1.278	0.423	0.01502
83.5	1.327	0.472	0.01002
∞	1.412	0.557	....
			0.01464

Tables IV and V show that alum inverts sugar rapidly.[1] The values of C in Table V, are only about half as large as those in Table IV. It seems that a change decreasing the number of molecules in the solution must be going on in this case as time elapses; the matter was not studied further, but it deserves investigation. The value of C in Table IV is the more reliable one. The inversion in case of the alum solution is caused by the aluminum sulphate present, which is hydrolyzed. It is a well-known fact that a solution obtained by mixing potassium sulphate and aluminum sulphate in molecular proportions, is the same as an equivalent solution of alum. Table VI shows that the potassium sulphate is not the cause of the inversion, and Table VII clearly shows that the aluminum sulphate is the active agent.

TABLE VI.

Potassium Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{2}$ g. mol. K_2SO_4. (Polariscope.)

Time, hours.	Rotation.	Change.
0.0	22.54	....
3.0	22.40	0.14
16.5	22.06	0.46
25.0	22.22	0.32

TABLE VII.

Aluminum Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{12}$ g. mol. $Al_2(SO_4)_3$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	22.54°	....	.....
3.5	16.39	6.15	0.02884
6.0	12.32	10.22	0.03058
8.0	9.91	12.63	0.03012
10.0	7.26	15.28	0.03244
14.0	4.14	18.40	0.03006
21.0	—0.26	22.80	0.03028
24.0	—1.64	24.18	0.03055
29.0	—3.10	25.64	0.02993
37.0	—4.82	27.36	0.03001
55.0	—6.44	28.98	0.02980
∞	—7.12	29.66	.....
			0.03026

[1] The same was found by Long: *l. c.*

Table VII shows that the aluminum sulphate solution inverts very rapidly, a little over one-fourth as rapidly as does centi-normal hydrochloric acid (Tables II and III). As the solution used in TableVII is not equivalent to that in Table IV, the constants are not directly comparable. We should expect alum to invert less rapidly, however, than an equivalent amount of aluminum sulphate, for the presence of the potassium sulphate tends to decrease the number of hydrogen ions in the solution.[1]

TABLE VIII.

Aluminum Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{6}$ g. mol. $AlCl_3$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0	22.47°	....	.....
6	6.92	15.55	0.0539
18	—1.98	24.45	0.0366
25	—4.44	26.91	0.0417
45	—6.45	28.92	0.0365
∞	—7.13	29.59	.....
			0.0422

The chloride was of Schuchardt's make. It was recrystallized three times. A comparison of Tables VII and VIII shows that the chloride inverts much faster than the sulphate. This is what one would be inclined to expect from the strong ionizing tendency of chlorine. (This point will come up again below.) Long found that ferrous chloride inverts much more rapidly than ferrous sulphate.

MANGANESE SALTS.

TABLE IX.

Manganous Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $MnSO_4$. (Polariscope.)

Time, hours.	Rotation.
0	21.64°
5	22.12
10	22.20
15	22.34
20	22.10
25	22.50
35	22.14

[1] Long found that ferrous sulphate inverts faster than ferrous ammonium sulphate, which illustrates the same point.

Table IX shows that manganous sulphate does not invert sugar appreciably at 55.5° C. The readings obtained vary irregularly within the limits of experimental error. At higher temperatures this salt does invert sugar, but of course very slowly (compare Long: *l. c.*).

TABLE X.

Manganous Chloride.

In 1000 cc., ½ g. mol. $C_{12}H_{22}O_{11}$ plus ¼ g. mol. $MnCl_2$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	22.79°	....	.....
5.5	22.72	0.07	0.000185
12.0	22.65	0.14	0.000170
24.0	22.54	0.25	0.000152
36.0	22.45	0.34	0.000138
48.0	22.23	0.56	0.000171
300 (about)	21.92	0.87	.....
∞	—7.12	29.91	.....
			0.000163

Table X shows that manganous chloride does invert slightly. Here again we see that the chloride inverts faster than the sulphate. In working at 80° C., Long also found that manganous chloride inverts much more rapidly than does the sulphate.

ZINC SALTS.

Of the zinc salts only the sulphate was tested. The specimen was a particularly fine one. Table XI shows that the inversion caused by this salt at 55.5° is very slight, but little change having taken place in fifty hours.

TABLE XI.

Zinc Sulphate.

In 1000 cc., ½ g. mol. $C_{12}H_{22}O_{11}$ plus ¼ g. mol. $ZnSO_4$. (Polariscope.)

Time, hours.	Rotation.
0.0	22.52°
2.0	22.38
6.0	22.38
20.66	22.42
46.0	22.02
50.0	21.96

The same solution heated in a water-bath to 100° C. gave the results in Table XII.

TABLE XII.

Zinc Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $ZnSO_4$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	21.96°	....	.....
1.0	18.84	3.12	0.04929
2.0	15.00	6.96	0.05940
3.0	12.22	9.74	0.05904
4.5	3.84	18.12	0.09417
8.16	—3.50	25.46	0.11089
∞	—7.12	29.08	.....

After three to four hours' heating the solution became colored. An acid odor was also perceptible. After three hours the values of C ran up rapidly. Long also noted an increase in the value of the coefficient at 80° C.

CADMIUM SALTS.

Cadmium sulphate inverts very slowly indeed as both the polariscopic and cryoscopic tests show (Table XIII). The inversion is practically nil.

TABLE XIII.

Cadmium Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CdSO_4$. (Polariscope.)

Time, hours.	Rotation.	Freezing-point lowering.
0.0	22.23°	1.720°
5	22.49	1.756
10	22.72	1.745
15	22.58	1.747
19	22.54	1.754
24	22.75	1.758
34	22.65	1.755
44	22.72	1.754

Cadmium chloride was tested and gave similar results, as Table 14 shows. This salt was particularly pure.

TABLE XIV.

Cadmium Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CdCl_2$. (Polariscope.)

Time, hours.	Rotation.
0.0	22.30°
2.0	22.54
3.0	22.62
8.0	22.62
5.0	22.60
18.0	22.28
26.0	22.46
46.25	....

Another fine-looking sample of cadmium chloride of Schuchardt's manufacture was tested by both the polariscope and freezing-point methods. This salt, which was not recrystallized, yielded the results in Tables XV and XVI.

TABLE XV.

Cadmium Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CdCl_2$. (Polariscope.)

Time, hours.	Rotation	Change.	C.
0.0	21.63°	....	.....
3	7.57(?)	13.06	0.08375
16	5.94	15.69	0.05430
10	—0.28	21.91	0.05793
15	—3.82	25.45	0.05612
20	—5.71	27.34	0.05474
25	—6.90	28.53	0.05576
35	—7.70	29.33	0.05346
∞	....	29.73	.....

TABLE XVI.

Cadmium Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CdCl_2$. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0	2.872°	....	.....
3	2.176(?)	....	.....
6	3.584	0.712	0.07389
10	3.700	0.828	0.05916
15	3.836	0.964	0.05822
20	3.919	1.047	0.06134
25	3.960	1.098	0.07480
35	3.977	1.105	0.08390
∞	3.986	1.114	.....

The values of C in Table XVI are somewhat higher and more irregular than those of Table XV. This is to be ascribed to the difficulty in working with such strong solutions by the freezing-point method. The values of C in both tables seemed abnormally high, however, and consequently the salt was recrystallized twice and then tested again, this time with the polariscope only. Table XVII gives the results found.

TABLE XVII.

Cadmium Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CdCl_2$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0	22.60°	....	.....
4	22.12	0.48	0.00177
20	20.85	1.75	0.00132
30	20.28	2.32	0.00121
45	19.61	2.99	0.00102
70	18.75	3.85	0.00086
100	17.88	4.72	0.00075
∞	—7.13	29.73	.....

The values of C in Table XVII continually decrease. They are much smaller than those in Tables XV and XVI, which shows that recrystallization further purified the salt by removing free acid that probably adhered to it. Long found a relatively very high coefficient for this salt at 80° C. He states that the salt he used was recrystallized several times, and was free from uncombined acid. As the above work shows that pure cadmium chloride inverts exceedingly slowly at 55.5° C., the inference must be drawn that the rate of inversion of sugar by this salt increases rapidly as the temperature rises. To test this inference, the same salt as was used to obtain the results in Table XIV was investigated at 100° C. Table XVIII gives the results obtained, which show that the inversion does increase enormously with the temperature.

TABLE XVIII.

Cadmium Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{2}$ g. mol. $CdCl_2$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0.0	22.54°	....	.....
1.0	11.16	11.38	0.21011
1.5	7.48	15.06	0.20511
2.0	3.82	18.72	0.21645
2.5	1.30	21.24	0.21859
3.0	—0.46	23.00	0.21606
4.5	—4.80	27.34	0.24554
7.0	—6.42	28.96	0.23158
∞	—7.13	29.67	.....
			0.22049

NICKEL SALTS.

Only one salt of nickel, the sulphate, was tested. The salt was a very pure specimen; it was recrystallized several times to free it from any excess of acid. The results in Table XIX show that the salt inverts slowly. The reaction progresses very slowly after about ten hours.

TABLE XIX.

Nickel Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $NiSO_4$. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0	1.713°	....	.....
1	1.728	0.015	0.00589
2.5	1.731	0.018	0.00283
4.5	1.740	0.027	0.00237
9.75	1.772	0.059	0.00243
38.5	1.765	0.052	0.00054
∞	2.827	1.114	.....

COPPER SALTS.

The rate of inversion by both the sulphate and chloride of copper was determined by means of the freezing-point method. Both salts were very fine samples. The sulphate was recrystallized three times and the chloride twice. In Table XX, the values of C gradually diminish to the sixteenth hour after which they increase. This increase is due to a reduction which the salt suffers after prolonged heating even at 55.5°. The last tube taken from the bath contained a deposit of metallic copper. This explains the high value of the final coefficient C.

TABLE XX.

Copper Sulphate.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CuSO_4$. (Polariscope.)

Time, hours.	Lowering.	Change.	C.
0	1.690°	....	.....
1.25	1.721	0.031	0.00973
3.25	1.744	0.054	0.00661
5.25	1.754	0.064	0.00489
8.25	1.770	0.080	0.00392
12.25	1.795	0.105	0.00351
16.25	1.860	0.170	0.00442
28.75	2.407	0.717	0.15586
∞	2.804	1.114	.....

TABLE XXI.

Copper Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{4}$ g. mol. $CuSO_4$. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0	2.446°	....	.....
2	2.452	0.006	0.00118
5	2.484	0.038	0.00302
8	2.525	0.079	0.00400
12	2.595	0.149	0.00520
17	2.721	0.275	0.00726
23	2.836	0.390	0.00816
29	2.980	0.534	0.00980
45	3.365	0.919	0.01690
65	3.560	0.114	.....
∞	3.560	0.114	.....

In Table XXI, the values of C continually increase. This may be due to a reduction of the salt; the solution, however, remained clear from beginning to end. The inversion is complete in sixty-five hours. Comparing this table with the preceding one, it appears that the chloride inverts more slowly than the sulphate for about the first eight hours; after that, the former inverts much more rapidly. The final value of the coefficient in Table XX is, of course, abnormally high for the reason already mentioned.

MERCURY SALTS.

Of these salts only mercuric chloride was studied. The specimen used was a sublimed product. It was not recrystallized from water. Both the polariscopic and cryoscopic methods were used. The solutions became somewhat turbid toward the latter part of the reaction, probably because of a slight reduction of the salt to mercurous chloride, which separated out. This necessitated filtration of the solutions before they could be tested with the polariscope.

TABLE XXII.

Mercuric Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{5}$ g. mol. $HgCl_2$. (Polariscope.)

Time, hours.	Rotation.	Change.	C.
0	22.59°	....	.....
0.5	22.38	0.21	0.00616
2	21.88	0.71	0.00525
4	21.20	1.39	0.00520
7	20.19	2.40	0.00522
12	18.57	4.02	0.00526
17	16.11	6.48	0.00628
22	14.13	8.46	0.00661
∞	—7.12	29.71	.....
			0.00572

TABLE XXIII.

Mercuric Chloride.

In 1000 cc., $\frac{1}{2}$ g. mol. $C_{12}H_{22}O_{11}$ plus $\frac{1}{8}$ g. mol. $HgCl_2$. (Freezing-point.)

Time, hours.	Lowering.	Change.	C.
0	1.293°	....	.....
0.5	1.295	0.002	0.00158
2	1.323	0.030	0.00593
4	1.338	0.045	0.00448
7	1.376	0.083	0.00481
12	1.432	0.139	0.00482
17	1.519	0.226	0.00579
22	1.603	0.310	0.00644
32	1.674	0.381	0.00568
∞	2.407	1.114	.....
			0.00542

The first coefficient in Table XXIII is very low. The experimental error in this case is, of course, relatively very great, since the increase of the lowering in half an hour is so small. No reliance whatever can be put on this first coefficient, and it has not been taken into consideration in the average. A comparison of the coefficients of Tables XXII and XXIII shows again the usefulness of the cryoscopic method in tracing the process of inversion, in spite of the many difficulties that are met in applying the method.

FERRIC SALTS.

Ferric potassium alum and ferric ammonium alum were tested, but the salts soon suffered reduction. A precipitate formed in these solutions in less than an hour and continued to increase rapidly. The sugar was speedily inverted as a few freezing-point tests showed.

AMMONIUM SALTS.

The effect of ammonium sulphate was studied at 55.5° and at 100°. No appreciable inversion took place at either temperature, although the mixture was kept at 55.5° for about sixty-seven hours. At 100° the solution turned brown after five hours' heating and, as it was being investigated with the polariscope, no more readings were made after that time. Ammonium chloride was tested only at the lower temperature. The readings showed

that after heating for eighty hours a change of only 0.1° in rotation had taken place. Even this might have been error of observation.

In Table XXIV are collected the coefficients of inversion at 55.5° C. for solutions that are half-normal with respect to sugar and half-normal (equivalent) with respect to the salt. Those marked with an asterisk (*) are only rough averages, since the coefficients in the series are not constant. In the last column is given the degree of hydrolysis deduced by comparing the speed of inversion of the salt with that of centinormal hydrochloric acid under the same conditions. The comparison is only very rough at best.

TABLE XXIV.

Salt.	C.	Hydrolysis per cent. in equivalent half-normal solution.
Aluminum sulphate	0.03026	0.52
Aluminum chloride	0.0422	0.73
Manganese sulphate	....	....
Manganese chloride	0.00016	0.003
Zinc sulphate	....	....
Cadmium sulphate	....	....
Cadmium chloride	0.0014*	0.024
Nickel sulphate	0.00281*	0.048
Copper sulphate	0.00551*	0.095
Copper chloride	0.00694*	0.12
Mercuric chloride ($\frac{n}{4}$)	0.00572	0.2
Hydrogen chloride ($\frac{n}{100}$)	0.1158	....

Theoretical Considerations.

The hydrolytic decomposition of a salt may be expressed by the general equation:

$$MA + H_2O = MOH + HA,$$

in which M represents the metal and A the acid radical. If the metal has several valences, correspondingly more molecules of water enter into the reaction. The more dilute the solution is, the greater is the extent of the hydrolysis. If for the sake of simplicity we assume the solution to be so dilute that the electrolytic dissociation of the salt is practically complete, the reaction takes the form:

$$\overset{+}{M}, \overset{-}{A} + H_2O = MOH + \overset{+}{H}, \overset{-}{A}.$$

From this it appears that A remains in the ionic condition throughout. There must, of course, be present an equal number of cations in order to preserve the electrical neutrality of the solution. These cations are mainly those of the metal (if the salt is but slightly hydrolyzed), but there are also present hydrogen ions formed as indicated by the equation. The compound MOH, the hydroxide of the metal, is probably held in solution in colloidal form, in which case its molecules are polymerized. In stronger solutions this hydroxide may unite with undissociated molecules of the salt to form a basic compoud, which would gradually be broken upon further dilution. In general then at any stage of dilution a solution of a salt of a heavy metal contains (1) a certain number of undissociated molecules of the salt, (2) the anions of the electrolytically dissociated molecules, (3) ions of the metal plus hydrogen ions together chemically equivalent to the anions, (4) molecules of colloidal hydroxide of the metal or of a basic salt equivalent to the hydrogen ions. At each stage of dilution an equilibrium between these various classes of molecules establishes itself.

The acid radical A becoming ionized, forces positive ions to form. If the metal is such that it readily passes into the ionic condition (*e. g.*, the alkalies and alkaline earths), practically the only positive ions in the solution are those of the metal, and the solution has a neutral reaction and does not invert sugar; but if the metal assumes the ionic state less readily (*e. g.*, the heavy metals), the ions of the metal form up to a certain extent only, the rest of the necessary positive ions being supplied by the water, which is decomposed, yielding hydrogen ions and an hydroxyl residue that forms either a colloidal hydroxide of the metal or a basic salt, as already pointed out. It is clear that if the metal readily enters into such colloidal or basic combinations the formation of hydrogen ions will be aided thereby. In a solution of a ferric salt, the deepening of the color on further dilution indicates the presence of the colloidal hydroxide or very basic salt, whereas the acid reaction, the high electrical conductivity, the power to invert sugar, etc., indicate the presence of hydrogen ions. In solutions of other salts, the presence of the colloidal or basic compound is generally not as readily detected, either because it is less abundant or because it is color-

less, and hence is less easily discovered. Colloidal hydroxides of some of the metals are well known, of others such substances are not known; but nearly all of the heavy metals form basic salts with more or less readiness. In most solutions the amount of such colloidal or basic compounds is small, the hydrolysis generally being less than one per cent. and but seldom exceeding three per cent.

For equivalent strengths of solutions the relative extent of the hydrolysis of salts of the same anion is determined by the readiness with which the various metals pass into the ionic state and the ease with which they form basic or colloidal compounds. The tendency that the metals have to pass from the metallic to the ionic condition is expressed by the so-called electrolytic solution tensions of the metals. These have been calculated from the differences of potential existing between the metals and normal solutions of their salts.[1] Since the passing of a metal from the metallic to the ionic state is not identical with the formation of cations from a salt after the latter is once formed, we should not expect to find a simple relation between the solution tensions of the metals and the degree to which their salts are hydrolyzed. Leaving out of consideration the tendency of the metal to enter colloidal or basic combinations, it might be expected, however, that the order in which the salts of the heavy metals of the same anion invert sugar be the same as that in the table of their solution tensions. This is in general found to be the case. According to Neumann[2] the order of the metals in the table of their solution tensions is: Aluminum, manganese, zinc, cadmium, iron, nickel, lead, copper, mercury.[3] Taking the results of Walker and Aston as given above and arranging the metals in the order in which their nitrates invert sugar, beginning with the one causing least inversion, we have: Cadmium, zinc, lead, aluminum. Here aluminum is last instead of first, and the order of cadmium and zinc is the reverse of that in the electrochemical series given above. A consideration of Long's results gives the order: Manganese, zinc, iron, aluminum for the sulfates, and manganese, iron, lead,[4] cadmium for

[1] Compare Neumann: *Ztschr. phys. Chem.*, **14**, 223 and 229; also LeBlanc's Elektrochemie, pp. 183 and 185.
[2] *Loc. cit.*
[3] Only those metals whose salts have been investigated as to their sugar-inverting power are here given.
[4] Taken from the nitrate.

the chlorides. According to the present investigation the order for the sulphates is: Nickel, copper, aluminum, the sulphates of manganese, zinc and cadmium having caused practically no inversion at 55.5°. The order for the chlorides is: Manganese, cadmium, copper, mercury, aluminum. While it is apparent that the order is, in general, similar to that in the electrochemical series, it is clear that aluminum is a striking exception, its salts being the most hydrolyzed of those tested instead of the least. According to Walker and Aston and also according to Long, the position of cadmium is lower in the series than it should be. The present work indicates that the inversion by cadmium chloride is especially influenced by temperature, and as the electrochemical series was determined at room temperature and the inversion was carried out at high temperatures, this might account for the abnormal position of cadmium. It remains to consider the relatively high degree of hydrolysis of aluminum salts. This metal, like iron in the ferric state, forms a colloidal hydroxide. According to the above considerations, this tendency of aluminum would aid the hydrolytic decomposition of its salts. The freezing-point results on alum solutions, indicating that a diminution of the number of molecules in solution occurs, deserves further study in this connection.

The results of Long, and also those contained in the foregoing tables, show that chlorides invert faster than sulphates. The explanation lies in the fact that chlorine has a greater tendency to pass into the ionic state than has SO_4. Hence in the solutions of the chlorides the number of anions is relatively greater and consequently the number of cations is also greater, resulting in an increase of the number of hydrogen ions and consequently more rapid inversion.

Summary.

The main results of this investigation may be summed up briefly as follows:

1. The freezing-point method may be successfully employed in determining the speed of the inversion of sugar.

2. When the metals are arranged in a series according to the speed with which their salts of the same acid radical invert sugar, it appears that the order is similar to that of the electro-

chemical series. Aluminum forms a notable exception. In spite of the high position of this metal in the electrochemical series, its salts invert sugar more rapidly than those of any other metal thus far tested.

3. Chlorides invert sugar more rapidly than sulphates, because the ionizing tendency of chlorine is greater than that of the sulphuric radical.

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[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE CASE SCHOOL OF APPLIED SCIENCE, NO. 32.]

SODIUM ALUMINATE AS A MEANS FOR THE REMOVAL OF LIME AND SUSPENDED MATTER FROM WATER FOR USE IN BOILERS.[1]

BY CHARLES F. MABERY AND EDWIN B. BALTZLEY.

Received October 5, 1898.

THROUGHOUT the section of country including Northern Pennsylvania, Ohio, and farther west, in districts removed from the lake or the large rivers, the only sources of water in seasons of drought are deep wells. Since the water from these wells contains large quantities of lime salts, there are serious difficulties in the way of procuring water suitable for use in steam boilers, especially in locomotive boilers. Even such water as that from Lake Erie or the rivers, deposit scale to such an extent as to occasion extreme inconvenience. In stationary boilers, the deposition of scale may be avoided at least in part by using some one of the many so-called scale preventatives, if the boiler is in charge of an intelligent engineer.

The inconvenience of boiler scale, the additional cost in fuel, the injury to the boiler, and the danger are features of this question familiar to all who have charge of boilers. The large masses of scale withdrawn from boilers in which hard or turbid water is used, are not surprising when the great quantities of water evaporated in boilers under high pressures are taken into consideration.

The wide variations in the composition of boiler scale are de-

[1] The work described in this paper formed the subject of a thesis for the degree of Bachelor of Science.

pendent on the differences in the water used. The manner of running the boiler has much to do with the hardness of the scale and the rapidity of its formation. The chief causes of the formation of scale are the calcium carbonate and sulphate and magnesium carbonate contained in solution, and the solid matter held in suspension, both inorganic and organic. All these points must be borne in mind if unpurified water is to be used in a boiler. There has been for some time a feeling on the part of engineers that the only satisfactory method for the prevention of boiler scale is the use of purified water, and many attempts have been made, with more or less success, toward purification of the water before it enters the boiler. The means that have been tried include sedimentation, precipitation by sodium carbonate, sodium hydroxide, slaked lime either alone or in combination. Evidently successful purification depends on removing completely the suspended matter as well as the precipitation of the lime and magnesia. In thinking of what combination should most effectually and economically accomplish these results, in any hard or turbid water, it occurred to one of us (Mabery), that sodium aluminate should fulfill the conditions demanded, and in trying this reagent we find that it meets all requirements.

The general method includes the preparation of sodium aluminate in solution. This may be done in any suitable tank or reservoir, by adding sodium hydroxide in the proper amount to a solution of aluminum sulphate of known strength, and adding to the water a definite amount (the quantity depending on the composition of the water to be purified), agitating thoroughly, and allowing the mixture to stand some time, perhaps twelve to twenty-four hours. The method is based on the following reactions:

For the formation of sodium aluminate:

$$Al_2(SO_4)_3 + 8NaOH = Al_2O_4Na_2 + 3Na_2SO_4 + 4H_2O.$$

In the precipitation:

$$CaH_2(CO_3)_2 + Al_2O_4Na_2 + 2H_2O = CaCO_3 + 2AlO_3H_3 + Na_2CO_3.$$

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4.$$

Similar reactions evidently take place with magnesium carbonate or sulphate. No doubt sodium aluminate can be made much more cheaply by fusing a tolerably pure clay with

soda-ash. Doubtless it may also be obtained cheaply as one of the products in the preparation of soda-ash from cryolite.

Numerous experiments were made with different proportions of sodium aluminate; the best results were obtained by using from one-half the calculated proportions to the calculated proportions of aluminum sulphate, depending on the composition of the water. With proper proportions of aluminate, aluminum hydroxide was completely precipitated on standing. Experiments on different waters with one-fourth the calculated proportion of aluminate showed that this amount was not sufficient to precipitate the lime sufficiently. In applying this method its effect was studied on waters containing different amounts of carbonate and sulphate, as well as on waters with a great variation in turbidity, from the slightly turbid lake water, to specimens thick and muddy. In every instance after standing from twelve to twenty-four hours, the water became perfectly clear. The extent to which lime and magnesia were removed is shown by results obtained in the following waters:

Very hard water from well in Ohio:

Calcium sulphate	259.0
Calcium carbonate	146.0
Magnesium carbonate	177.3

About eighty-five per cent. of the amount of aluminate required to precipitate all the lime and magnesia was added, air was blown through the solution for a few minutes and the mixture allowed to stand twenty-four hours. Analysis then showed that eighty-eight per cent. of the lime had been removed and 95.6 per cent. of the magnesia. In another determination the theoretical amount of aluminate was added and the solution treated as before. Analysis showed that 98.1 per cent. of the lime had been removed and 97.4 per cent. of the magnesia.

The next water tried was the Massillon city water, containing

Calcium sulphate	99.12
Calcium carbonate	113.2
Magnesium carbonate	131.1

After treatment with the theoretical amount of sodium aluminate the total lime removed was equivalent to 98.8 per cent., and that of magnesia 98.0 per cent.

In another experiment, using one-half the theoretical amount, the lime removed was 83.5 per cent., and that of the magnesia 90.6 per cent.

The next water tried was a very turbid sample from the Cuyahoga river. This water was very muddy and did not settle on long standing. It is used in boilers. A clear sample of this water showed the following composition:

Calcium sulphate	68.0
Calcium carbonate	14.14
Magnesium carbonate	21.3

Treatment with the theoretical amount of aluminate gave unsatisfactory results.

With twice the theoretical amount, the lime remaining was 88.3 per cent., and the magnesia 84.5 per cent. The aluminate is especially serviceable in such waters as this in removing completely the turbidity.

Although the water of Lake Erie does not contain a large proportion of solid matter, it forms scale quite rapidly unless some means are taken to prevent it. Analysis of a sample collected April 28, 1898, gave:

Calcium carbonate	53.63
Calcium sulphate	32.61
Magnesium carbonate	21.53

Analysis, after treatment with theoretical aluminate, gave 97.6 per cent. lime, and 93.2 per cent. magnesia removed, after standing thirty-six hours. With one-half the theoretical amount standing forty-eight hours 98.3 per cent. of the lime was removed and ninety per cent. of the magnesia. With one-fourth the theoretical amount eighty-three per cent. of lime was removed and sixty per cent. of the magnesia.

From a very muddy brook water containing much suspended matter, with

Calcium sulphate	8.1
Calcium carbonate	120.0
Magnesium carbonate	23.0

after standing forty-eight hours, the theoretical amount of aluminate removed ninety-six per cent. of lime and ninety-six per cent. of magnesia. One-half the theoretical amount removed 94.6 per cent. lime and 94.4 per cent. magnesia.

In treating the water from a well in Ashtabula, O., containing

Calcium sulphate	96
Magnesium sulphate	39

the theoretical amount of aluminate removed 98.3 per cent. of the lime and ninety-six per cent. of the magnesia.

A well in Glenville, O., containing

Calcium carbonate	99
Calcium sulphate	36
Magnesium carbonate	23

after treatment with theoretical aluminate showed that 98.1 per cent. of the lime had been removed and ninety-five per cent. of the magnesia.

To test still further the efficiency of the aluminate, experiments were made with sodium hydroxide alone, using various proportions, but the removal of lime was not much more than half the quantity taken out by aluminate, and the magnesia was not affected. An important effect of alumina is to remove suspended matter which it does rapidly and completely.

THE HEAT OF BROMINATION TEST FOR OILS.

By Augustus H. Gill and Israel Hatch, Jr.

Received October 5, 1898.

THIS test occupies a middle position between the Maumené and Hübl tests; it suffers from the disadvantages that the required apparatus is not always obtainable, and that the results obtained with different apparatus are not comparable. The object of the investigation was to simplify the apparatus and to ascertain if some substance could not be found with which the rise of temperature could be compared, and thus a "specific temperature reaction" obtained similar to the Maumené test.

Apparatus and reagents required; twenty-five cc. graduated flask; five cc. pipette; burette; thermometer divided into 0.2° calorimeter; measuring apparatus; bromine; carbon tetrachloride.

The calorimeter consists of a flat-bottomed glass tube about three quarters of an inch in internal diameter, and four inches long. This is held by a cork in a beaker two inches in diameter, thus making an air-jacket, and the beaker placed in-

side a four inch beaker, the space being filled with cotton waste; this cotton jacket guards against drafts.

The measuring apparatus is that devised by Wiley,[1] and consists of a filter bottle, through the neck of which passes the five cc. pipette carried by a rubber stopper. The side-neck is fitted with a blowing bulb; by pressing this bulb the liquid in the bottle is forced up into the pipette. One serves for the oil, and the other for the bromine solution.

The bromine solution is prepared by measuring from the burette one volume of bromine into four volumes of carbon tetrachloride, measured with the flask; it is kept in the filter bottle.

Five grams of the oil (ten grams of a tallow or neatsfoot oil and two and one half grams of a drying oil) are weighed out into the twenty-five cc. flask, and made up to the mark with carbon tetrachloride; it is then poured into the measuring apparatus. Five cc. of this solution are accurately withdrawn and run into the calorimeter, care being taken not to allow it to flow down the sides. The thermometer is inserted and, when the temperature has become constant, the reading is taken. Five cc. of the bromine solution measured out similarly to the oil, are allowed to flow down the sides of the calorimeter and mix with the oil; the reaction is instantaneous, and the highest temperature is noted. The mixture is poured out of the calorimeter, the latter wiped out, and allowed to cool before further use. At least three observations should be made, and the results should agree within 0.5°.

Notes: During the addition of the bromine solution to the oil the mixture should not be stirred, as the hot liquid will be cooled by contact with the sides of the calorimeter.

As in the Maumené test, the two solutions should be at the same temperature, which they will be if kept in the same room.

It was found that the bromine solution did not keep well longer than two days; hence a large quantity should not be prepared at one time.

Chloroform gives a slightly higher rise than over carbon tetrachloride, as would be expected; this was found to be 1.7° with the apparatus here described. Archbutt[2] and Jenkins[3] find

[1] This Journal, 18, 378.
[2] *J. Soc. Chem. Ind.*, 16, 309.
[3] *Ibid.*, 193.

that the presence of water either in the bromine or the oil is apparently of no influence.

The results obtained vary with each calorimeter; hence to make them comparable they must, as in the Maumené test, be referred to some standard. Such a standard has been found in sublimed camphor, which can be prepared in sufficient purity; seven and five-tenths grams are dissolved in carbon tetrachloride and brominated, giving an average rise of 4.2°. The rises in temperature obtained with the various oils were divided by this number, giving a specific temperature reaction; if this be multiplied by a factor—found by dividing several of the iodine numbers by this specific temperature—the iodine value of any sample may be quite closely determined; this is shown in the following table, the factor being 17.18.

TABLE SHOWING THE RELATION OF THE BROMINATION AND IODINE VALUES.

Name of oil.	Spec. temp. Reaction.	Iodine. Calculated.	Found.
Neats-foot	3.286	56.5	59.1
Tallow	3.348	57.4	57.2
Prime lard	3.715	63.8	63.8
Sperm	4.191	72.1	73.2
No. 1 lard	4.096	70.3	73.9
Olive	4.762	81.8	82.0
Cottonseed	5.667	97.3	103.0
Corn	6.381	109.5	107.8
Cod	8.002	137.4	135.0
Linseed	9.049	155.6	160.0
25° paraffin	1.643	28.2	10.1
300° lantern	1.190	20.5	0.0

In the case of the hydrocarbon oils the discrepancy may be due to the fact that there is substitution by the bromine and none with the iodine.

MASS. INSTITUTE OF TECHNOLOGY,
October, 1898.

THE ANALYTICAL CONSTANTS OF AMERICAN LINSEED OIL.

BY AUGUSTUS H. GILL AND AUGUSTUS C. LAMB.
Received October 5, 1898.

GENUINE samples of linseed oil having been found to yield lower iodine values than were usually accepted, it seemed desirable to determine the constants of some American oils of undoubted purity.

Nearly all the principal brands in the market were represented, being obtained from leading manufacturers in the east and west, whom we here wish to thank for their courtesy. The methods employed were those in common use, described at length in a little book by one of us[1]; it was found necessary in applying the Maumené test to mix the linseed oil thoroughly with a heavy petroleum and allow to stand an hour or two before the treatment with sulphuric acid, correcting for this in the rise obtained.

The results are given in the accompanying table and are the mean of two closely agreeing determinations.

CONSTANTS OF LINSEED OIL.

	Brand.	Specific gravity at 15.5°C.	Valenta test °C.	Maumené test, °C.	Iodine absorption in per cent. in 4 hrs.	Iodine absorption in per cent. in 18 hrs.	Drying test, hours required.
1.	Western raw	0.933	79	97	174.7	180	72
2.	" "	0.932	70	90	169.7	180	72
3.	" " special ...	0.934	73	105	178.0	178	72
4.	Old Calcutta	0.931	71.5	106	167.5	178	72
5.	Eastern oil	0.931	73	105	168.0	168	72
6.	Western boiled	0.936	74	100	178.8	178.8	18
7.	Eastern "	0.938	59.5	101	169.5	171	18
8.	Acid bleached.....	0.934	52.5	103	160.0	160	84
9.	Bleached without acid .	0.932	60	105	162.0	162	84
10.	Menhaden oil.....	0.934	73.5	135	157.0	181	84
Usual constants.....		0.931–0.937	57–74	103–126		170–188	
Average.....		0.934		111		176	

Samples 1, 6, and 8 are from the same house, as also are 5 and 7; sample 10, menhaden oil, was examined because it is used as a substitute for, and an adulterant of, linseed oil. Its effect would be to raise the Maumené test, lower the iodine value, and retard the drying properties of the oil. It will be noticed that the constants here given differ from those usually accepted in that the Maumené and iodine tests are about ten and four per cent. lower, respectively.

It is to be noted further that, contrary to the experience of Dieterich[2], the iodine value is not, in the majority of cases, perceptibly increased by eighteen hours' standing.

[1] Gill: A Short Handbook of Oil Analysis.

[2] *J. Soc. Chem. Ind.*, **12**, 381.

ON A BALANCE FOR USE IN COURSES IN ELEMENTARY CHEMISTRY.

By C. E. Linebarger.

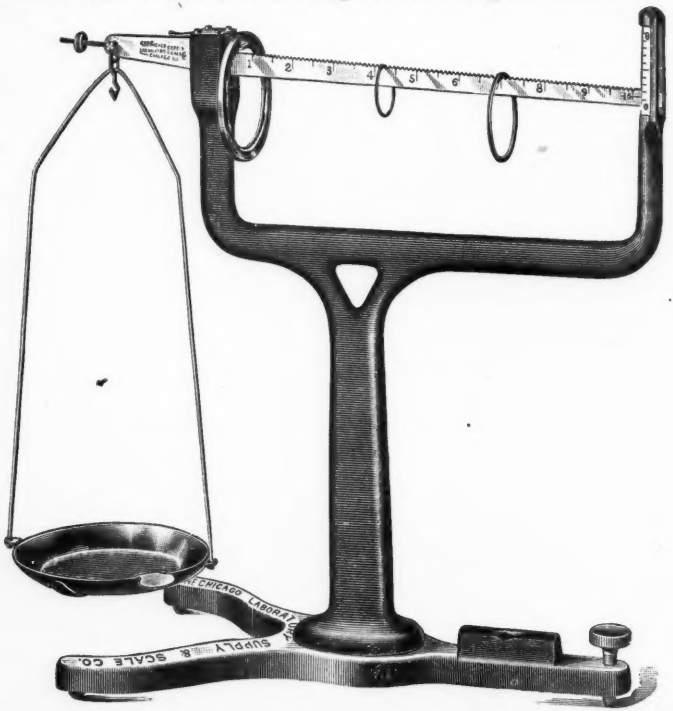
Received June 16, 1898.

IT is now probably almost universally recognized that an elementary laboratory course in chemistry should include some experiments involving the use of the balance; that quantitative as well as qualitative work should be done by the student. Indeed, it seems that the fundamental laws of the science could not be really appreciated without some quantitative experiments being performed. Of course, such work cannot be done with expensive and delicate balances, as the beginning student has neither the time nor the requisite skill to handle them, not to speak of the cost. I think it will be admitted that a balance weighing to a centigram or so is all-sufficient. The balance should also weigh rapidly, and, as generally the weighing is done at the desk where the student does the rest of his work, the balance should take up a minimum amount of room, and should allow of frequent removal from desk to desk without getting out of adjustment.

One of the most vexatious things about the use of a balance in elementary classes is the loss and deterioration of the weights. No matter how careful instructors and students may be, weights will get lost or will have acid spilled upon them; and their replacement is, to say the least, bothersome. A balance that is not subject to this evil and is at the same time rapid, compact, and sufficiently accurate is shown in the accompanying cut.

As is seen, it has unequal arms, their ratio being as four is to one. The longer arm twenty cm. is divided into 100 equal parts, notches being made at the points of division. The weights consist of three riders weighing 25, 2.5, and 0.25 gram, respectively; in weighing, the positions they occupy when equilibrium is attained, show at a glance the desired weight. Thus, the reading in the cut is 7.42 grams. The riders are given a ring-shape so that they form an integral part of the balance; they are thus secured against loss. When any of them are not needed, they may be placed on a horizontal

arm above the beam and are thus out of the way; their sizes are such that they slip easily through one another. The capacity of the balance is 111.0 grams; it is sensible to 0.005 gram with no load, and to about 0.01 gram with an average load. The up and down motion of the pan is so slight and the lateral motion of the beam so limited by stops that but little damage can be done to the steel knife edges, even though a careless stu-



dent might perchance throw the object to be weighed upon the pan. Not only is the room taken by the balance itself small, but the room that would be occupied by weights is entirely spared. To prevent corrosion as much as possible, most of the parts are lacquered in black with white and gold lettering; not only is this finish durable, but it also prevents, in a measure, the balance appearing old from usage.

The balance is made by the Chicago Laboratory Supply and Scale Company, 31–45 West Randolph Street, and will be known as the "Chaslyn Balance."

THE DETERMINATION OF POTASH AS PERCHLORATE.

By F. S. Shiver.

Received July 14, 1898.

THE increasing use of potash salts for fertilizing purposes has made the determination of potash a question of prime importance to the agricultural chemist.

The desire to devise a method at the same time rapid and accurate has been manifested in many ways in the past few years, especially in Germany, the seat of the great potash deposits.

The German chemists believe they have solved the problem in the so-called Stassfurt method, which as all know permits of the separation of the potash by platinum chloride after previous precipitation of sulphuric acid by barium chloride in slight excess, and in a strongly acid solution. This method with practice is quite accurate and rapid, with a slight tendency, however, to high results in my hands. It possesses little advantage over the Lindo-Gladding method, in so far as rapidity and accuracy are concerned.

The following determinations were made by the Stassfurt method--potassium sulphate, C. P., and potassium chloride, C. P., were mixed with such impurities as to imitate the composition of commercial sulphate of potash, sulphate of potash and magnesia, kainit, and muriate.

Table I.

	K_2SO_4 used. Gram.	K_2SO_4 found. Gram.	Error on K_2SO_4. Gram.	Error on K_2O. Gram.
Sulphate of potash	0.3284	0.3291	+0.0007	+0.0004
		0.3289	+0.0005	+0.0003
Sulphate of potash and magnesia	0.1856	0.1863	+0.0007	+0.0004
		0.1870	+0.0014	+0.0008
Kainit	0.1000	0.1003	+0.0003	+0.0002
		0.1009	+0.0009	+0.0005
	KCl used. Gram.	KCl found. Gram.	Error on KCl. Gram.	Error on K_2O. Gram.
Muriate	0.2506	0.2498	—0.0008	—0.0005
	0.2522	0.2514	—0.0008	—0.0005

The factor used for converting potassium platinichloride into potassium sulphate was 0.35694 which is practically the same

as that recommended in the Stassfurt method; *viz.*, 0.357. The factor used for converting potassium platinichloride into potassium chloride was 0.30557 which is practically the same as that recommended in the Stassfurt method; *viz.*, 0.3056. It will be seen from the above results that the method is quite accurate with a tendency, however, to slightly high results.

In view of the increasing importance of the potash determination, it is highly desirable that we should possess a check method, rapid and accurate, based on some other principle of separation than that with platinum chloride.

All of our present methods for the determination of potash, involve the use of platinum chloride as a means of final separation, and hence they are all subject to the same general sources of error, such as solubility of the platinichloride in the eighty per cent. wash alcohol used, etc.

Of all the salts which potassium forms with acids, none are as well adapted for furnishing the basis of another process as the perchlorate, which is nearly insoluble in strong alcohol.

As all the compounds which perchloric acid forms with the bases other than potash and ammonia are soluble in alcohol, we may readily deduce the basis of another process. The determination of potash as perchlorate, is an old process due to Sérullas who first noticed the insolubility of the salt in alcohol, and to Schloesing who made it the basis of a new process. Schloesing's process, improved later by Kraut has, however, not come generally into use since the same produces inaccurate results.

W. Wense[1] has made the process usefulsince he diminishes the solvent action of the alcohol on the perchlorate through the addition of slight quantities of perchloric acid. He describes the following course of procedure:

The solution to be investigated is evaporated, after once freeing it of sulphuric acid and non-volatile acids with perchloric acid in a porcelain dish. In order to wash the perchlorate easily it is desirable to produce the same in a granular condition. This is attained by warming the solution containing the potash on a water-bath before adding the perchloric acid, which must be run in drop by drop. In all cases there are used about one and a half to one and three-quarters times the amount of perchloric acid necessary for the decomposition of the salt present.

[1] *Ztschr. angew. Chem.*, *1891*, 691, and *1892*, 233.

After the addition of the perchloric acid the solution is evaporated, until all odor of hydrochloric acid or other volatile acids has disappeared. For washing the precipitate ninety-six per cent. alcohol is used, to which two-tenths per cent. of its weight in perchloric acid is added.

The residue from the evaporation is treated with ten cc. of the alcoholic wash solution, which may take up only $\frac{1}{20,000}$ of a part of potassium perchlorate, and the salt mass is then broken up with a stirrer.

Decantation is performed through a weighed filter, which has been previously dried at 120°–130° C., when the breaking up of the salt mass is repeated, and the residue again treated with the alcohol wash solution. The precipitate is then brought on the filter, and freed of the adhering perchloric acid solution by washing with a few cc. of pure alcohol. The filter is then pressed between folds of filter-paper, dried for twenty-five minutes at 120°–130° C., and weighed.

One part of potassium perchlorate corresponds to 0.5382 part of potassium chloride, and 0.6289 part of potassium sulphate.

According to the author the whole washing with a good pump occupies only a short time, and requires fifty to seventy grams of alcohol. If the substance to be investigated contains sulphuric acid, the same is to be removed in the usual way by barium chloride previous to the determination of the potash. The author who used the method in the investigation of potassium chloride, C. P., commercial muriate, kainit, and carnallite obtained, according to the analyses reported, very favorable results.

R. Caspari[1] recommends collecting the potassium perchlorate in tubes containing asbestos filters, and subsequent drying for twenty minutes at 130°–150° C. The tubes are allowed to cool in a desiccator, or in the air, and then weighed.

According to Caspari the method is applicable for fertilizers, ashes, and the like, in the presence of phosphoric acid, alkaline earths, iron, alumina and manganese, if the following method of procedure is adopted:

After the removal of sulphuric acid, the hydrochloric acid solution is evaporated for the purpose of getting rid of the free

[1] *Ztschr. angew. Chem.*, *1893*, 68.

acid, the residue stirred with twenty cc. of hot water after which perchloric acid is added in quantity not less than one and a half times that necessary for the decomposition of all salts present.

The solution is now evaporated with frequent stirring to a sirupy consistency, some hot water is again added, and the solution evaporated still again with occasional stirring until the disappearance of all odor of hydrochloric acid, and till the appearance of white fumes of perchloric acid. An evaporation of large quantities of perchloric acid is to be avoided. If this takes place, more perchloric acid is to be added.

The cooled, more or less sirupy, contents of the dish are well stirred up with about twenty cc. of wash alcohol (ninety-six per cent. alcohol containing two-tenths per cent. perchloric acid), taking care however not to reduce the potassium perchlorate to a fine powder. After the alcoholic solution has become clear, it is decanted through the asbestos filters, the washing repeated with the same quantity of wash alcohol, allowed to settle and decanted again.

The residue remaining in the dish is freed of alcohol by gently warming, evaporating again with about three-tenths gram of perchloric acid and a little water, and washing the cooled mass with several cc. of alcohol, with which it is also brought into the filters and the perchlorate in the tubes finally covered with a little pure alcohol. The potassium perchlorate obtained in this way contains, according to Caspari, no phosphoric acid, or only slight quantities of the same ; on an average only 0.00057 gram phosphoric acid.

In the separation of sulphuric acid, Caspari seeks to avoid, as much as possible, a loss of potash, since he precipitates in a strong hydrochloric acid solution at the boiling temperature with a concentrated solution of barium chloride, made acid with hydrochloric acid. Experiments of the author prove also the applicability of the method in the presence of other acids not volatile on the water-bath, as chromic acid, and also boric, tartaric, and oxalic acids. If ammonium salts are present they are to be removed either with soda-lye or milk of lime, by gentle heating or through careful ignition.

A. Kreider[1] has followed the method as described by Caspari, and has obtained very satisfactory results. Kreider found the Gooch crucible preferable in the filtering of the perchlorate and recommends the same instead of the tubes proposed by Caspari. In the presence of phosphoric acid, the previous separation of which is not necessary, it appeared advisable according to Kreider's experiments to allow the perchlorate precipitate to stand with an excess of perchloric acid before treating with alcohol.

Six determinations made of potassium unmixed with other bases or non-volatile acids gave the following results:

In two cases the theoretical amount of potash (K_2O) was recovered as perchlorate; in three cases there was a loss of 0.0002 gram; and in one case a loss of 0.0003 gram; one-tenth gram of potassium chloride was operated on in all cases. In order to repeat Kreider's work, and to ascertain the accuracy of the process the following work was undertaken. A solution of chemically pure potassium chloride was prepared by dissolving 1.0005 grams in 200 cc. water. One cc. of the solution was found to contain 0.005 gram potassium chloride, aliquot portions being measured from a burette, evaporated, dried, and weighed.

In all the work here reported the method as proposed by Caspari with the use of the Gooch crucible as suggested by Kreider was employed.

However in the first three experiments reported the perchlorate was collected on paper filters as suggested by Wense, washed in the usual way, dried, and the perchlorate dissolved in hot water, and the solutions evaporated to dryness in platinum dishes and weighed.

In all cases the weighed perchlorate was a little discolored, due to the fact that the paper filters had been acted on to a slight extent by the perchloric acid, causing them to char a little around the edges during the process of drying. In the subsequent leaching with hot water, some of this carbonaceous material dissolved, and went in solution with the perchlorate.

The results obtained by weighing in dishes as above described were as follows:

[1] *Am. J. Sci.*, 49, 443.

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The results obtained by weighing in dishes as above described were as follows:

[1] *Am. J. Sci.*, 49, 443.

TABLE I.

	KCl solution used. cc.	Equivalent to KCl. Gram.	KCl found. Gram.	Error on KCl. Gram.	Error on K_2O. Gram.
I	6.2	0.0310	0.0310	+0.0000	+0.0000
II	8.1	0.0405	0.0411	+0.0006	+0.0004
III	5.0	0.0250	0.0253	+0.0003	+0.0002
Average		0.0322	0.0325	+0.0003	+0.0002

It will thus be seen that the average error in these determinations is 0.0003 gram KCl; it is possible that this slight plus error is due to the slight discoloration already noticed, and the weighing in dishes is not to be recommended though the results obtained are sufficiently accurate for all practical purposes. In the other experiments which follow the potassium chloride was weighed out directly for analysis, and the perchlorate was collected always in a Gooch crucible.

TABLE II.

	KCl used. Gram.	KCl found. Gram.	Error on KCl. Gram.	Error on K_2O. Gram.
I	0.0848	0.0859	0.0011	+0.0007
II	0.0217	0.0217	0.0000	0.0000
III	0.0419	0.0413	−0.0006	−0.0004
IV	0.1007	0.1009	+0.0002	+0.0001
V	0.1003	0.1015	+0.0012	+0.0008
VI	0.1016	0.1015	−0.0001	−0.0000
VII	0.0217	0.0210	−0.0007	−0.0004
Average	0.0675	0.0677	+0.0002	+0.0001

In the above determinations No. I was among the first made, and it is possible that the slightly high results obtained were due to lack of familiarity with the method. Excluding No. I, the average would be as follows:

KCl used. Gram.	KCl found. Gram.	Error on KCl. Gram.	Error on K_2O. Gram.
0.0647	0.0647	0.0000	0.0000

It would thus appear that the determination of potash as perchlorate in mixtures free from other bases and non-volatile acids, is quite accurate, equally as much as the determination by platinum salt.

After nitrogen and phosphoric acid, potash is the compound one has mostly to determine in fertilizers, plants, and soils. The potash is usually combined with sulphuric, nitric, or carbonic acid, and more rarely with phosphoric acid.

These salts are almost always associated with alkaline salts and the alkaline earths. It is now therefore a question of the applicability of the perchloric acid method to the determination of potash when associated with these other bases, and non-volatile acids, such as sulphuric and phosphoric acid. In regard to the bases it has been contended by some that magnesia is a disturbing element in the determination of potash by perchloric acid.

Schloesing has shown, however, that in the following mixture, after the removal of sulphuric acid by barium chloride and conversion of bases into perchlorates, the magnesia did not have any disturbing effect.

	Gram.
Potassium chloride	0.0835
Magnesium sulphate	0.5740
Sodium chloride	0.1298
Calcium chloride	0.2330

In this mixture, there was recovered, by proceeding as above stated, 0.0814 gram potassium chloride. Kreider has also shown that magnesia has no disturbing effect. He treated 0.1500 gram magnesium carbonate with perchloric acid, evaporated till fumes of perchloric acid appeared and cooled, when magnesium perchlorate crystallized; on treating this with alcohol a perfectly clear solution was obtained. It was also thought that it was necessary to remove all non-volatile acids, previous to the separation of the potash as perchlorate. Caspari and Kreider have, however, shown that it is only necessary to remove sulphuric acid. In order to secure a nearly complete separation of phosphoric acid from the potassium, Kreider has shown that a considerable excess of perchloric acid should be left upon the potassium perchlorate before it is treated with the alcohol.

Kreider's results on a mixture containing

	Gram.
Potassium chloride	0.1
Magnesium sulphate	0.13
Aluminum sulphate	0.05
Sodium phosphate	0.4
Calcium carbonate	0.13
Ferric chloride	0.05
Manganese dioxide	0.05

were quite promising as will be seen from the results reported in the *American Journal of Science*, **49**, 448.

The method as modified by Caspari and Kreider is quite promising, and I hope in the near future to do some further work on the determination of potassium associated with other bases and non-volatile acids.

Preparation of Perchloric Acid.

As perchloric acid is not a regular article of commerce it becomes necessary for each one desiring it to make his own supply. There may be mentioned briefly four methods for its preparation and the literature in which detailed directions may be found.

The Method as Proposed by Schloesing.—Prepare first potassium perchlorate from potassium chlorate by heating in the usual way. The mass after the decomposition of the chlorate is treated with boiling water, and then rapidly cooled; the crystals of potassium perchlorate separate; the potassium chloride remains in solution with some of the perchlorate also. The perchlorate is then dissolved and treated with sufficient quantity of hydrofluosilicic acid to obtain the potassium fluosilicate, the perchloric acid being liberated. After standing a while the precipitate is filtered off, and the filtered solution containing the perchloric acid is concentrated and treated with ammonia. The ammonia salt is next decomposed by hydrochloric and nitric acids, and the solution then evaporated on a water-bath to a sirupy consistency.

The solution is left in this condition for a day or two, to separate further any crystals of potassium perchlorate it may contain. The supernatant liquid is then ready for use after a blank experiment has been conducted with the same.

Process of Perrey.—Perrey has sought to avoid completely the presence of potash in the reagent. He makes use of the principle recognized first by Sérullas that chloric acid, distilled, furnishes a third of its weight of perchloric acid. Barium chlorate, a salt easily prepared, is dissolved in water, and the solution precipitated with sulphuric acid, leaving the chlorate, however, in slight excess. After filtration the solution is concentrated and distilled, the distillate being collected for use as soon as white vapors show themselves in the body of the retort.

The product which one receives is contaminated with a little chloric acid and chlorine which can be expelled on the water-bath. The yield of perchloric acid is about the same as in the

Schloesing process. For details of these two processes consult Grandeau: "Traité d'Analyse des Matières agricoles," 1, 88–91.

Caspari's Method.—This method is quite similar in principle to the method described by Schloesing. Potassium chlorate is used as a basis, potassium perchlorate being prepared from it in the usual way. The potassium perchlorate dissolved in water is then treated with hydrofluosilicic acid at the boiling temperature, the reaction being as follows:

$$2KClO_4 + H_2SiF_6 = K_2SiF_6 + 2HClO_4.$$

The solution is then filtered on an asbestos filter under pressure, the clear filtrate evaporated on a steam-bath to small bulk, and allowed to stand for twenty-four hours, whereby is effected the separation of any remaining potassium fluosilicate or perchlorate. It is again filtered and diluted with an equal quantity of water and barium chloride added in slight excess to remove last traces of sulphuric acid and hydrofluosilicic acid. The clear supernatant liquid is then poured off and evaporated on a water-bath till white fumes of perchloric acid appear.

The solution is then, after allowing any potassium perchlorate that may be present to separate again, diluted with water and the excess of barium salt most carefully removed with sulphuric acid. The solution is allowed to stand for several days, then filtered through paper, and is ready for use.

For details of the process consult Wiley's Agricultural Analysis, **2**, 290, and *Ztschr. angew. Chem.*, *1898*, p. 68.

Kreider's Method.—By far the most simple and rapid of all the methods proposed for the preparation of perchloric acid is that worked out by Kreider. The method depends upon the production of sodium perchlorate from sodium chlorate by heating, in the usual way, the subsequent decomposition of the sodium perchlorate by hydrochloric acid with the liberation of perchloric acid and the precipitation of sodium chloride which is separated by decantation or filtration. The filtered solution is concentrated on a water-bath till white fumes of perchloric acid appear, then cooled and diluted with water when it is ready for use.

It is manifest that the acid thus prepared is not chemically pure, since sodium chloride is not absolutely insoluble in hydrochloric acid, but if a portion of the acid prepared as above be

tested with silver nitrate it will be readily seen that any sodium chloride which may have remained in solution, has been converted into perchlorate. Furthermore, unless the sodium chlorate used contained some potassium or on evaporation the acid was exposed to fumes of ammonia, the residue from the evaporation of a portion of the acid prepared as above, will be entirely soluble in alcohol, and the presence of any sodium perchlorate is therefore entirely unobjectionable.

I have in the course of my work on this subject prepared the acid by this method several times, and have always found the process very satisfactory, requiring but little time and attention. In my work, however, I found, as the result of blank determination on the acid thus prepared, a very small residue insoluble in alcohol for which in all cases corrections were made. This correction was very slight, and in no way condemns the process, since it is a very simple matter to determine it once for all on any lot of acid, and make the proper use of the same in the actual determination.

For detail of the process consult Kreider's article in the *American Journal of Science*, **49**, 445–446.

[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS.]

IMPROVED APPARATUS.

BY J. L. SAMMIS.

Received October 10, 1898.

BURETTE.

THE frequent use of Mohr's burette with Geissler's glass stop-cock during the past summer called the writer's attention to two points which, it was thought, might be improved.

The handle of the glass stop-cock, as usually made, is turned toward the right. Right-handed persons usually find it easier to operate the stop-cock with the left hand and stir or shake the titrated liquid with the right. In order to facilitate this, the stop-cock of a burette was cut off and sealed on again with its handle toward the left. See Fig. 1.

In titrating, much care has to be exercised lest the mark upon the float should sink below the graduations on the

scale of the burette. To render this impossible and to enable one to see more easily the scale and the titrated liquid at the same time, the tip of the burette was elongated to about fourteen inches by sealing in a piece of glass tubing between the stop-cock and the constricted extremity. This elongated tip was bent to the front and a little to the right just below the stop-cock, and then upwards. Two more bends were so placed that the end of the tip was about three inches in front and one inch to the right of the lowest mark upon the fifty cc. burette. By this arrangement, with the stop-cock wide open, not a drop of liquid will flow out after the liquid meniscus in the burette has reached the level of the end of the tip, which, as described, is just opposite the fifty cc. mark of the scale. If the tip be placed a little higher up, say opposite the forty-nine cc. mark, the instrument may be used with a float or without. The long narrow burette with the new tip can be held much closer to the table by the burette clamp, and the easy reading of the upper end of the scale is thereby facilitated.

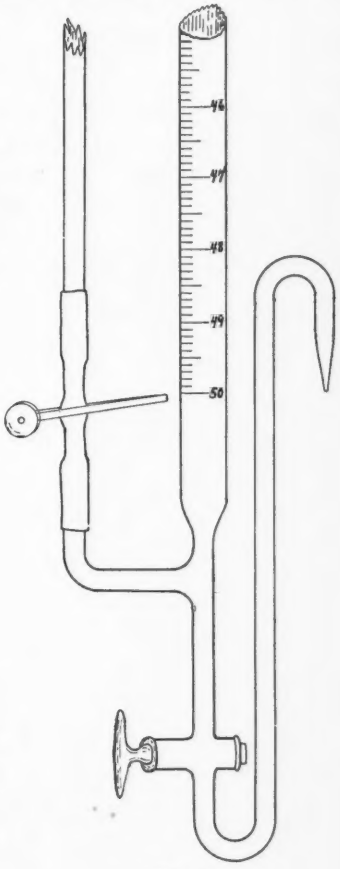


FIG. 1.

ELECTRIC HEATER ADAPTED FOR USE IN ETHER EXTRACTION.

During the past year, a large number of extractions with Sohxlet's apparatus have been performed in this laboratory. In

order to continue this operation during the night time without the danger of fire, an electric heater was devised which could be put in operation by closing a switch and which kept the water at the proper temperature as long as desired. The heater (Fig. 2) is made of coils of No. 24, soft iron wire, wrapped upon a brass rod, and insulated from the rod and from each other by thin sheet asbestos. The winding was done rapidly by placing in

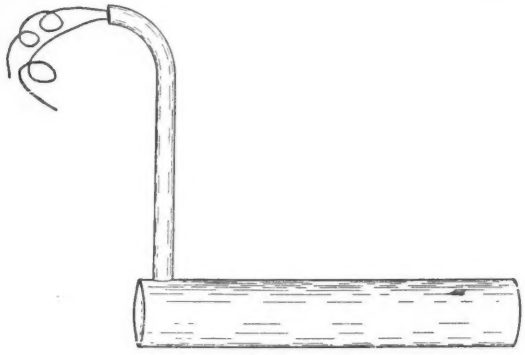


FIG. 2.

the lathe chuck a brass rod six inches long and three-eighths of an inch in diameter, laying a sheet of asbestos paper over it, and winding on the wire, keeping the turns about one-thirty-second of an inch apart to prevent short circuiting. Having wound one coil, a second sheet of asbestos is put on, and a second coil wound on it, and so on until the desired resistance is obtained. The ends of the iron wire are soldered to short pieces of No. 12 insulated copper wire which serve to bring in the electric current. The cylinder thus made is slipped into a closely fitting tube of sheet copper and the ends of the latter are soldered on. A small hole or notch is left at one end of the copper tube through which the insulated wires pass. These copper wires are pushed through a narrow piece of brass tubing about four inches long, and the tubing is soldered to the copper cylinder in a position perpendicular to the axis of the latter. The heater is placed in a four-holed water-bath and the brass tube with the copper wires is pushed up through a small hole made in one corner of the top of the bath. The tube may be soldered to the

edges of the hole. The ends of the copper wires are made fast to binding posts, screwed into a narrow strip of wood upon the front of the battery of water-baths.

One heater is required for each four-holed water-bath, and the heaters are connected in parallel. The length of the iron wire in one heater is seventy feet, and its resistance when hot is twenty-six ohms. The potential difference across the ends of the heating coils is fifty-two volts, thus using two amperes of current and 104 watts per heater. The heat generated is sufficient to keep the water in the bath at 65° C., and the ether in the extraction apparatus falls from the condenser at the rate of twenty or twenty-five drops per minute. The currents from a storage battery and from a 125-volt dynamo have been used to run this apparatus with perfect success, and with little attention and no risk of fire.

September 25, 1898.

GLYCOLLIC ACID: ONE OF THE ACIDS OF SUGAR-CANE.

By Edmund C. Shorey.

Received September 26, 1898.

IN continuing work on organic non-sugar in sugar-cane, indicated in a paper[1] "On the Principal Amid of Sugar-Cane," glycollic acid was prepared from the sugar-cane amid by the action of nitrous acid,

$$CH_2NH_2COOH + HNO_2 = CH_2OHCOOH + N_2 + H_2O$$

and the acid so obtained compared in chemical and physical properties with glycollic acid obtained from other sources, monochloracetic acid, hippuric acid, etc. The samples of glycollic acid obtained in various ways were found to be identical in every respect with that obtained from the sugar-cane amid.

The presence of glycollic acid as such in sugar-cane was, in a sense, discovered by accident, and its isolation and identification is of considerable interest to the sugar manufacturer, the analyst, and the student of plant physiology. It was noted that on adding a few drops of strong nitric acid to a sample of cane juice, clarified for the polariscope in the usual way, with a slight excess of lead subacetate, a white crystalline precipitate was thrown down. This, on examination, was found to contain

[1] This Journal, 19, 11.

lead, and on decomposing with hydrogen sulphide gave an acid solution, which, on evaporation to a sirup, deposited needle-shaped crystals, generally grouped in radiating clusters. These crystals were exactly the same in appearance as those of glycollic acid, which had been prepared from various sources, and were found to possess the same chemical and physical properties. To further verify the identity of the various preparations with glycollic acid, this acid was prepared by still another method; *viz.*, by the action of caustic potash on sulphonic acetic acid,

$$CH_2\begin{matrix}SO_2OH\\COOH\end{matrix} + KOH = CH_2\begin{matrix}OH\\COOH\end{matrix} + KHSO_3.$$

The glycollic acid formed in this case was the same in every respect as that which had already been prepared by other methods.

The crystalline precipitate thrown down by nitric acid appears to be a mixture of normal and basic lead glycollates, containing from sixty to seventy per cent. of lead. The isolation of glycollic acid from cane juice in this way is open to the objection that it may have been formed from glycocoll by the action of some nitrous acid in the nitric acid, and may not occur as such in the cane. To remove this objection, advantage was taken of the sparing solubility of the copper salt, and the acid has been isolated from cane juice in quite large quantities by the following method:

The fresh cane juice was treated with an excess of freshly precipitated cupric hydroxide, washed thoroughly with cold water by decantation, and the precipitate treated with hydrogen sulphide, filtered from cupric sulphide, and the resulting acid solution evaporated until crystals began to form, when, on cooling, a solid mass of crystals was obtained. By this method glycollic acid equivalent to from seventy-five to eighty per cent. of the total acidity of the juice has been obtained; but its value as a quantitative method has not been established. Glycollic acid prepared in the various ways mentioned has been obtained in four-sided needle-shaped crystals generally arranged in tufts, soluble in water, alcohol, and ether, with a purely sour taste not unlike that of tartaric acid. If great care be taken not to carry

the evaporation of the solution too far, the crystals are quickly formed, are completely soluble in water again, are unchanged in the air, melt, turn brown, and decompose below 100° C., and give precipitates in neutral solution with lead acetate, mercuric nitrate, and cupric sulphate.

The most notable characteristic of glycollic acid is the ready formation of the anhydride. If the water solution be evaporated to dryness stopping short of the formation of brown color, the mass of crystals presents the same appearance as that obtained by careful evaporation noted above; but it rapidly deliquesces in the air, and on treating with water a portion is found to be insoluble as white flocks or as a white powder. This insoluble portion is the anhydride, part of which is dissolved by the acid remaining, resulting, if not too dilute, in a thick solution not unlike vaseline, from which needles of glycollic acid are slowly deposited. If the free acid be neutralized with caustic soda the whole of the anhydride is precipitated.

In some respects glycollic acid resembles malic acid, and might, in some cases, be confounded with it, but it differs at the following points:

1. Glycollic acid is more readily obtained in crystalline form.

2. It is optically inactive: natural malic acid appears to be always optically active, being right- or left-handed as it is more or less concentrated.

3. The lead precipitate obtained from neutral solution of glycollic acid is soluble in acetic acid and insoluble in strong ammonia.

4. On heating, glycollic acid chars and suffers decomposition, the chief product of which is formic acid. Malic acid decomposes into maleic and fumaric acids, which can readily be identified.

Aconitic acid has often been stated to be present in sugar-cane, and for this reason the glycollic acid in cane juice might be mistaken for it, but they can readily be distinguished by the fact that aconitic acid melts at 140° C., boils at 160° C., decomposing into itaconic acid and carbon dioxide. I have before me, at the present writing, preparations of glycollic acid made in the following ways:

1. By the action of nitrous acid on glycocoll, obtained from hippuric acid.

2. By the action of nitrous acid on glycocoll obtained from sugar-cane.

3. Obtained directly from cane juice by treatment with cupric hydroxide and subsequent decomposition with hydrogen sulphide.

4. By the action of caustic potash on sulphonic acetic acid and isolation as the copper salt, as above.

These four preparations are exactly the same in appearance, and I have not been able to find any physical or chemical test, by which one can be distinguished from another.

To the sugar manufacturer the presence of glycollic acid presents the following points of interest: In evaporating cane juice in multiple-effect evaporators, acid vapors are sometimes given off and the free acid can be found in the condensed vapor from the following drum, or under other conditions the acid is found in this water in combination. In the *Planters' Monthly* (Honolulu), **15**, 8, E. Hartmann has shown that these condensed vapors contain organic acids, chiefly formic, in combination with iron. Hartmann assumes that the formic acid results from the oxidation of sugar in the process of evaporation; but, as I have already noted, glycollic acid is decomposed below 100° C., giving formic acid as one product of decomposition, and it is quite possible for this decomposition to take place in cane juice under certain conditions.

The formic acid, given off on heating glycollic acid, I have identified by its general physical properties, its action on silver nitrate, and by its conversion into the copper salt, the anhydrous salt containing 41.1 per cent. copper. The exact behavior and conditions under which free glycollic acid and the calcium salt decompose, or undergo change, when heated in sugar solutions, are not yet determined, and, as subjects of future study, present possible explanation of several hitherto unexplained facts in sugar-house work. Three of these may be briefly noted:

1. It is known that if raw acid cane juice be boiled or evaporated, it becomes less acid, and it is also well known that starting with cane juice exactly neutral, the molasses from the second or third sugar may be quite acid, without any fermentation hav-

ing taken place. The ease with which glycollic acid is converted into the anhydride, which is a neutral body, and the fact that the anhydride, on long boiling with water, is converted into the acid again, have a very probable connection with these facts.

2. The natural coloring-matter of cane juice is quite different from that which results from the processes of sugar manufacture, and which causes largely the dark color of low-grade sugars and molasses. The former can be completely removed by lead subacetate, while the latter, which seems to partake of the nature of caramel, cannot, in many cases, be removed by any reagent. The ease with which glycollic acid chars or becomes brown when heated, explains probably the presence of a portion of this coloring-matter in low-grade products of the sugar house.

3. It is customary to boil low-grade molasses to a certain consistency known as "string proof," and molasses thus boiled is placed in coolers or wagons and allowed to remain until granulation has reached the point when the massecuite can be conveniently and profitably dried in centrifugal machines. It sometimes happens that in a short time, twenty-four to thirty-six hours after this massecuite has been placed in coolers or wagons, considerable frothing or foaming takes place, and a considerable portion of the massecuite runs over on the floor. In Louisiana, where it happens much more commonly than in Hawaii, this foaming is attributed to boiling at too high a temperature, 165° F. being considered the point beyond which it is not safe to go. In Hawaii this rule does not always apply, but when foaming takes place it undoubtedly is due to the decomposition of some body in the slowly cooling mass, and the gas resulting from this decomposition entangled in the viscous mass necessarily causes foaming. The presence of glycollic acid, a body easily decomposed at a comparatively low temperature, is not unlikely to be connected with this phenomenon.

To the sugar chemists the presence of glycollic acid in sugar-cane presents at least two points of interest: First as a possible explanation of the formation of the color of low-grade sugars and molasses which every worker with the polariscope finds so troublesome to remove; and second, as a probable explanation

of the impossibility of accurately estimating the total solids in cane juice by evaporating to dryness. When cane juice is evaporated to dryness, even in a vacuum, some of the bodies contained suffer decomposition into gaseous products, giving a residue less than the actual weight of solids originally held in solution; the decomposition of glycollic acid is no doubt responsible for a portion of this loss.

The presence of glycollic or hydroxyacetic acid, $CH_2OHCOOH$, in sugar-cane is full of suggestions to the physiologist. The principal amid of sugar-cane, glycocoll, CH_2NH_2COOH, is very closely related to this acid; in what relation do they stand in the plant? Is one formed from the other or have they each their separate rôle in the plant economy? Glycollic acid is readily obtained by oxidation of dextrose or levulose and so from cane-sugar; does it stand in any relation to the building-up of the cane-sugar in the plant? Glycocoll and glycollic acid are comparatively simple methyl compounds; how close do they stand to the supposedly simple first product of carbon assimilation? These and numerous other questions present themselves, —questions, the answers to which extend over the whole realm of plant physiology.

LABORATORY OF KOHALA SUGAR CO.,
KOHALA, HAWAII, Sept. 8, 1898.

A NEW APPARATUS FOR THE DETERMINATION OF VOLUME.[1]

BY CHAS. F. MCKENNA.

Received November 15, 1898.

THIS instrument has been devised in order to obviate certain objectionable features of those others, whose type is the Schumann or Candlot Volumenometer. Such objections are:

a. The reading is not delicate, since the caliber of the tube is large. Such instruments are limited in accuracy by our ability to read to 0.01 cc. This is obviously impossible in such tubes.

b. The solid must be introduced through the liquid on the lines where the reading is subsequently made. The slight coating here formed on the walls of the tube tends to increase the difficulty of making this observation correctly.

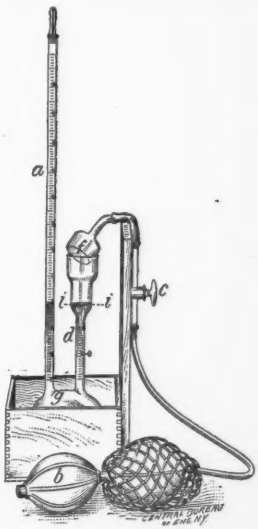
c. The ground joint by which the tube fits into the flask

[1] Read at the meeting of the New York Section, November 11, 1898.

usually leaks when a liquid like benzine is used. Any apparatus with a stop-cock in contact with the liquid is open to the same objection. An English form, recommended by Stanger and Blount, in which the tube is blown with the flask, is a good one.

In the apparatus I propose, the solid is introduced by one tube and the change of volume is measured on another one so slender that tenths of a cubic centimeter can be easily read and the hundredths quite accurately estimated.

The flask *g*, of about 175 cc. capacity, has two vertical tubulures blown into it; one, *a*, of the inner diameter of a pipette stem (five mm.) graduated in cubic centimeters and tenths, topped by a perforated glass stopper, and the other, *d*, with its middle portion similarly graduated for one or two cc. above and below a o mark, and this expanding into a receiving-tube about twenty-five mm. in diameter, closed by a ground-glass stopper *f*, with a glass tube prolong. This prolong is connected to a glass stop-cock and further on to a rubber bulb. The stop-cock, it will be noticed, is quite outside of the liquid-holding part of the apparatus.



In making a specific gravity determination of a mineral or other material in powder, begin by filling the flask through the receiving-tube with liquid up to a line about *ii*. Then place the stopper in above this, blow gently with the bulb and close the stop-cock *c* when the liquid stands in the tube *d* at the o mark. From this to the top of the column in *a* is the initial volume and the reading on *a* is to be noted.

Then remove *f*; the liquid flows back to *ii*, and presents a wide surface down through which a definite weight of the finely divided and dried powder can be sifted by using such an article as a porcelain Gooch crucible or a similar object spun from brass and fitting into the opening. Now replace *f* and blow the liquid

back. If any powder remains, the columns can be made to surge back and forth and carry every particle down. The column *d* is then forced down to 0, the stop-cock *c* turned to hold it there, and the reading taken at the top of the column in *a*.

To insulate the flask it is well to enclose it in a box and surround it with asbestos, sawdust, sand, or some such material that will guard against expansion or contraction of the volume of the liquid by the influence of surrounding things. Should the air or vapor in the space from the 0 mark to the stop-cock be subject to such influences any error from it is nullified by making a differential reading on the two columns. Thus, if the column is blown down to 0 and the reading in *a* is taken to be say 5.42, and a half minute afterwards it is noticed on stem *d* to be at —0.07, let *a* be immediately read again and it will be found to be

	5.49
	0.07
True volume as before,	5.42

Taking three sets of such readings on the initial volume and three on the final volume after the addition of the solid, conduces very much to accuracy and to a check upon one's estimations of the hundredths. Thus an actual case was:

Initial volume.	Final volume.
6.38—0.02 = 6.36	9.57—0.00 = 9.57
6.38—0.01 = 6.37	9.67—0.10 = 9.57
6.37—0.00 = 6.37	9.59—0.03 = 9.56
6.38—0.01 = 6.37	9.62—0.06 = 9.56
	9.67—0.10 = 9.57

An instrument, designed thus with longer stem to hold the increase of volume caused by fifty grams of material, would be more accurate than one designed for ten grams; but ten grams is a convenient weight, and when it is used a table of reciprocals hanging in front of the apparatus would enable one to read off the specific gravity at once upon noting the difference of volume, multiplying the reciprocal by ten.

In this way many delicate determinations of specific gravity can be made in immediate succession with considerable economy of time and labor.

NEW YORK, November 1, 1898.

[CONTRIBUTION FROM THE LABORATORY OF AGRICULTURAL CHEMISTRY, OHIO STATE UNIVERSITY.]

LIGHT A FACTOR IN SUGAR PRODUCTION.[1]

BY H. A. WEBER.

Received September 10, 1898.

THE fact that the United States is one of the greatest sugar-consuming nations of the world, and that about nine-tenths of the sugar consumed is imported at an annual cost of about $100,000,000, have given rise, from time to time, to attempts in the direction of a greater home production of sugar than is possible from the long-established sugar-cane industry of the Gulf States.

Owing to the geographical location of this country, only such sugar-producing plants could form the basis of these attempts, as were adapted to cultivation in the temperate zone. Of these plants only two need be mentioned here ; namely, sorghum and the sugar-beet.

As is well known the early efforts at sugar production from beets in this country were absolute failures. Various causes contributed to this result, prominent among which was the antipathy of the American farmer to accomodate himself to the cultivation of beets, which is much more irksome than the cultivation of ordinary agricultural crops, to which he had been accustomed, and which at that time brought him satisfactory returns for his labor. The country was not ripe for the establishment of the new industry.

In the late seventies and early eighties the experiments in making sugar from sorghum were at their height. This crop can be grown like corn, and its cultivation is much more in keeping with the tastes and practices of the American farmer, than that of the sugar-beet. Wherever sorghum sugar factories were established there was no difficulty whatever in securing an abundant supply of the cane delivered in proper shape at the mills. For a time the prospects of the sorghum sugar industry were bright. The sugar produced found a ready sale at remunerative prices, but, unfortunately for those who had embarked in the new enterprise, and fortunately for those who

[1] Read at the Boston Meeting of the American Association for the Advancement of Science.

were about to invest on a larger scale, the sorghum sugar industry, before it was fairly upon its feet, was confronted by a falling market, due to the overproduction of sugar in Europe and especially in Germany. This unexpected interference with the sugar market of the world, gradually brought the price of sugar and molasses down to a point where the manufacture of sugar from sorghum was no longer profitable, and the new industry which had excited general attention for three or four years had to succumb with all its investments, a total loss. It may be said in passing, that the sorghum sugar industry is dead for all time to come. The good old times for the manufacture of sugar, when yellow C sugar sold for eight cents per pound cash in car-load lots, are gone nevermore to return.

These fruitless attempts at the establishment of a sugar industry in this country have been thus briefly referred to, for the reason that they are still of importance to us for the lessons which they have taught.

The Department of Agriculture at Washington, under the able direction of Dr. Wiley, has for many years made valuable investigations in connection with the sugar industry; but with the advent of the present Secretary of Agriculture, a general interest in the subject of a home production of sugar has been renewed. The efforts of Secretary Wilson found the farmers throughout our country in a responsive mood, owing to the universal depression in agriculture for a number of years preceding his administration, and consequently during the past year in almost every county of many of the states, experimental plots of sugar-beets were grown.

Whether the establishment of this new agricultural industry in our country is advisable from an economic point of view or not, is a question foreign to this paper. This phase of the subject was ably discussed by Mr. Edward Atkinson in the *Forum* of November, *1897*, in an article which deserves the earnest consideration of all who are interested in the public welfare.

If, however, the efforts put forward should result in the establishment of a beet-sugar industry in this country capable of producing our home demand for sugar, it should be borne in mind that this object must be accomplished in the face of an overproduction of sugar in the world, a condition which twenty

years ago would not have been considered possible. This over-production of sugar has come to stay. The margin of profit will necessarily be low. Of our vast domain the insignificant area of 2,000,000 acres of land subjected to beet culture will suffice for the production of our home demand for sugar. Taking all these facts into consideration it is evident that the successful sugar factories will necessarily exist only in the most favorable localities, and in the course of a very short time factories blindly started in unfavorable localities will be crushed.

There are various conditions, which must be supplied for the production of a sugar-producing plant rich enough in sugar to meet the competition at present existing in the manufacture of this article of food, as well as certain facilities for operating a factory after the plants are grown. Prominent among the former conditions is the matter of light. The leaves are the laboratory in which the sugar is directly or indirectly synthesized and light is the agent.

All sugar-producing plants are equipped by nature with an abundant leaf surface, and when these plants are rescued from their unfavorable surroundings in wild vegetation and subjected to cultivation, their leafy organs are capable of elaborating and storing much more sugar than is necessary for the perpetuation of the species. This excess of production is utilized by man for the manufacture of sugar.

It would seem evident therefore that, other things being equal, the more light one of these plants could get during its period of vegetation, the higher its content of sugar would be. The truth of this proposition has been confirmed by numerous observations made upon sugar-producing plants.

Sugar-producing plants may be divided into two categories: (1) Those having a long period of vegetation, as the different varieties of southern cane, and (2) those having a short period of vegetation as sorghum and the sugar-beet. The former group of plants when cultivated in tropical regions grow luxuriantly for a period of eighteen months and at the end of this time the content of sugar in the juice reaches eighteen to twenty per cent. The crop of sugar-cane is, however, usually taken off after a period of twelve months, when the content of sugar in the juice is only fourteen to fifteen per cent.

The increase in amount of sugar in the longer period of vegetation is due to the greater amount of sunlight, to which the growing plants have been exposed. Owing to this long period of vegetation, southern cane is not so much affected by climatic conditions and suitable locations as is the case with plants of a short period of vegetation.

The latter group of sugar-producing plants, in which the present territory of this country is directly interested, are affected in many ways by the amount of light available during the period of vegetation, which on account of the present competition in the manufacture of sugar may mark prospective enterprises with success or failure as the case may be.

1. Climatic conditions must be taken into consideration in the location of sugar factories. Localities in which the seasons vary greatly in the amount of clear weather are not so well adapted to the growing of rich sugar plants as those in which clear weather during the growing season predominates every year. As an example illustrating this fact may be mentioned the experience of the writer in the investigation of sorghum as a sugar-producing plant.

The years 1880, 1881, and 1882 in the locality of Champaign, Illinois, were typical sugar seasons. During the summer months clear weather prevailed. The cane-sugar in the juice of the best varieties of sorghum reached thirteen to fourteen per cent. The coefficient of purity of the juice was high, and with proper precautions in treating the juice, sugar could readily be made even with crude apparatus. The years following were less favorable in this respect. In 1883, for example, cloudy weather with rain prevailed almost daily during the summer months. As a consequence the content of cane-sugar in the juice of the better varieties of sorghum only reached eight to ten per cent. The purity of the juice was correspondingly low, and the manufacture of sugar extremely difficult.

Four sorghum sugar factories were erected in consequence of the favorable results obtained in the preliminary experiments of 1880 and 1881 at Champaign, Illinois, conducted by Professor M. A. Scovell and the writer. It is safe to say, that if the weather of these two seasons had been similar to that of 1883, the factories would not have been started and the capital and labor invested in them lost.

The ideal localities in this respect are the arid plains of the western states, where the necessary soil moisture can be supplied by irrigation. Here, for a given degree of latitude, the maximum amount of light is available for the growing crop, and poor sugar seasons cannot occur.

2. The higher latitudes are more favorable, other things being equal, than the lower ones, owing to the greater length of the days and the longer duration of twilight.

The sorghum sugar industry again can furnish data illustrating this point. Among the numerous visitors from all parts of this country and from many foreign countries to the factory at Champaign, Illinois, was a party from Tennessee, who claimed that the "Sunny South" was the place for raising sorghum. Capital was raised, a factory erected at Franklin, Tennessee, and about 700 acres of sorghum were grown. The yield of the crop was heavy; but the sugar content of the juice was very disappointing, it being about four per cent. lower than that of sorghum grown in central Illinois, although the season was an ordinary one for that section of the country.

The plant from which the sugar-beet has been derived is indigenous along the shores of the Mediterranean Sea, but it has been developed into one of the most important sugar-producing plants in the latitudes of northern Germany and France.

The writer does not wish to be understood as claiming that a higher latitude is under all circumstances better than a lower latitude. The climatic conditions already mentioned, and other conditions to be considered further on, may more than compensate for the increase of light obtainable through a more northerly location.

3. Proximity to large bodies of water is favorable to sugar production. This is due to the fact that near the shore of such bodies of water and extending for a considerable distance inland, the location has the advantage of a more intense light, caused by the direct rays of the sun in addition to the light reflected from the surface of the water. The writer had an opportunity of investigating this point during the past season.

Sugar-beet seed of the Klein-Wanzleben variety was universally distributed over the state of Ohio by the Department of Agriculture at Washington, and also very generally planted for

experimental purposes. Samples of beets were obtained representing a section of the state from Lake Erie to the Ohio River. A sample consisted of four average beets of each field or plot from the largest size down to about one-half pound in weight. Each beet was wrapped in paper and the sample sent by express to our laboratory, to insure as slight a change as possible, and immediately analyzed. In addition, and in order that the results obtained might be strictly comparable, the percentage of juice was determined in each case.

Without going into details, the results of the investigation clearly indicate that the region of the state of Ohio bordering upon the lake has advantages in the raising of sugar-beets of high grade, which are not possessed by other portions of the state. The best samples of beets in the whole list were grown at Oak Harbor near Lake Erie. The smallest beet weighed twenty ounces and the largest twenty-nine ounces. The percentage of sugar in the juice was 16.3 and in the beets 15.68. The coefficient of purity was 81.71.

A sample grown at Locust Point on the lake exemplifies, in a high degree, the possibilities of the lake region in producing beets with a high content of sugar. The smallest beet of the sample weighed twenty-eight ounces and the largest 71.25 ounces or nearly four and five-tenths pounds. The percentage of sugar in the juice was 14.2 and in the beets 13.8 with a coefficient of purity of 81.42.

The same may be said of another sample grown at Locust Point. The smallest beet of this sample weighed 60.25 ounces and the largest 70.25 ounces. Even these enormous beets with an average weight of four pounds were found to be above the standard for content of sugar and purity of the juice, as generally accepted for the manufacture of sugar.

The remarkable richness of these overgrown beets becomes more apparent, when contrasted with a sample grown in Licking County in the central portion of the state. This beet weighed 40.75 ounces; the content of sugar was 8.47 per cent., and the purity 64.68 per cent.

Although some samples were obtained from other sections of the state, which were of good quality for the manufacture of sugar, yet other samples of the same sections fell below the

standard. The lake region alone produced beets, which were uniformly of a high grade, when all the requirements of a good beet were taken into account.

4. Topographical features of land are of importance in determining a suitable location for a sugar factory. It is well known that beets grown in the shade are worthless for the manufacture of sugar. In view of this fact it would seem almost superfluous to say that a partial obstruction of the direct rays of the sun daily would cause the production of a crop of beets of lower sugar content than would be the case if such obstruction did not occur. Consequently level tracts of land, where on clear days the plants are exposed to the direct rays of the sun from morning to night, must be better adapted to beet culture than deep valleys, especially if they are narrow and skirted by hills or mountains, and if in addition their general course is from north to south.

The writer is convinced that the variation in the composition of beets grown in the same sections of the country, having a diversified topography, is due in a great measure to the injudicious selection of the fields in this respect.

There are other factors which enter into the successful inauguration of the proposed new beet-sugar industry in this country, but, as a guide to the selection of the most favorable localities for its permanent establishment, the matter of light should receive due consideration.

COMMERCIAL IRON SILICIDES WITH A HIGH PERCENTAGE OF SILICON: THEIR PROPERTIES, MANUFACTURE, AND USES.

By G. de Chalmot.

Received August 26, 1898.

IRON silicides containing about eleven to thirteen per cent. silicon have, for some years, been made in blast-furnaces, and have been successfully introduced in the manufacture of iron and steel. It has been found impracticable to much increase the amount of silicon by the blast-furnace process. This can, however, be successfully done by changing the process and making use of the great heat of the electric furnace. I have made, in the electric furnace, silicon-iron alloys containing from

twelve to forty-six per cent. silicon. In alloys up to 46.5 per cent. silicon, and most probably in those up to fifty per cent. silicon, the iron and the silicon are chemically combined; *i. e.*, there is no free silicon and no free iron present. If more than fifty per cent. silicon is forced into the iron, the excess crystallizes out in small black crystals. This article deals only with silicides containing twenty-five to fifty per cent. of silicon.

COMPOSITION.

Silicides of from twenty-five to fifty per cent. silicon seem to consist of a mixture of two distinct compounds between iron and silicon; compound *a*, which contains twenty-five per cent., and compound *b*, which contains fifty per cent. silicon. These compounds are represented by the chemical formulas Fe_3Si_2 and $FeSi_2$. Both these compounds were obtained pure enough for analysis. When iron silicides with about twenty-five to twenty-eight per cent. of silicon are allowed to cool slowly from the liquid condition, compound *a* will crystallize out in very well-developed crystals, some of which will be as large as one-half inch to the side. These crystals have never been determined crystallographically. They have, among others, well-developed tetrahedral faces. These crystals are best obtained from an alloy containing from one to two per cent. silicon above twenty-five per cent. It is probable that some iron-silicon compound containing less than twenty-five per cent. silicon hinders the crystallization of the compound Fe_3Si_2.[1] Crystals obtained at various times and in different furnaces contained:

	1. Per cent.	2. Per cent.	3. Per cent.	Composition of Fe_3Si_2. Per cent.
Iron	74.75	....	75.89	75.00
Silicon	25.17	25.30	24.48	25.00

To isolate the compound *b*, I make use of the fact that acids attack the silicide faster the lower the content of silicon. I used a silicide containing about thirty-nine per cent. silicon, and which, according to my views, contains fifty-six per cent. of compound *b*, and forty-four per cent. of the compound *a*.

The acid used was hydrofluoric acid. This acid attacks both

[1] A most beautiful specimen of these crystals can be seen at the New York office of the Willson Aluminum Co. It is a piece of silicide of fifteen inches in diameter, on one side entirely composed of these crystals, some being among the best developed that were ever produced.

compounds rather easily, and in order to obtain any residue I had to work carefully and with moderation. The finely pulverized silicide was suspended in water and the acid added in successive small amounts. By thorough cooling, a too violent reaction was prevented. The acid added was not sufficient to dissolve the whole of the silicide. The residues, which were thus obtained, contain :

	1. Per cent.	2. Per cent.	3. Per cent.	Composition of $FeSi_2$. Per cent.
Iron	50.56	52.24	....	50.00
Silicon	49.71	48.26	49.35	50.00

The yield of residue was about twenty per cent. of the amount taken. Compound *b*, thus obtained, forms a gray crystalline powder quite unmagnetic.

I have obtained in the furnace an alloy containing : Iron 53.76 per cent., and silicon 46.22 per cent., which corresponds to a content of 84.88 per cent. of the compound *b*. This alloy was gray and crystalline, and could be easily pulverized.

Hahn has described an iron silicide of fifty per cent. silicon, which he produced in minute quantities by treating a twenty per cent. silicon alloy with hydrofluoric acid. He describes this compound as insoluble in hydrofluoric acid ; hence it is different from that which is found in my silicides. It was produced in an entirely different manner.

Among the combinations more likely to be present in my silicides, might be the compound FeSi with 33.3 per cent. silicon. Such a compound has been described by Hahn and by Fremy. It is not easy to show with certainty that such a compound is not present in these silicides, where we have to deal with a mixture of compounds having similar properties. It seems probable that this compound does not exist in my silicides. An alloy containing 31.4 per cent. silicon was taken. If the compound of 33.3 per cent. silicon existed, it would be present especially in this alloy in large quantities. We might expect this compound to contain 22.9 per cent. of compound *a*, of twenty-five per cent. silicon, and 77.1 per cent. of the compound with 33.3 per cent. silicon. On the other hand, if the compound of 33.3 per cent. silicon is not present the alloy would contain 74.4 per cent. of compound *a* of 25 per cent. silicon, and 25.6 per cent.

of compound *b* of fifty per cent. silicon. In the first case there is a great excess of the 33.3 per cent. compound, and we might expect that compound *a* could not form well-developed crystals. In the second case compound *a* being far in excess it would probably yield better-developed and larger crystals. I have pulverized the alloy of 31.4 per cent. silicon, to forty mesh sieve, and attacked it with such an amount of hydrofluoric acid as is not sufficient to dissolve the whole mass.

If now the first case be true, the compound *a* will be probably more soluble in acids than the other compound, which contains more silicon. This is a general rule among silicides. Compound *a* is only present in small amounts and is probably not present in large, well-developed crystals. The result will be that compound *a* will be quite or nearly dissolved, and some of the compound of 33.3 per cent. silicon will remain in a more or less pure condition. The residue will then contain more silicon than the original alloy.

In the second case there is a chance for a larger percentage of compound *b* than of compound *a* to be dissolved; for although the latter be more soluble in acids, it is present in large excess and probably in much larger and better-developed crystals than the compound *b*. If a larger proportion of compound *b* than of compound *a* should be dissolved, the residue will contain less silicon than the original alloy.

Acting on the coarsely powdered alloy of 31.4 per cent., silicon was found to produce a residue which contained less silicon than the original.

	Original alloy. Per cent.	Residue. Per cent.
Silicon.....	31.4	30.2

This result renders the presence of a compound FeSi doubtful.

PROPERTIES.

Iron silicides are invariably crystalline, and are white or gray in color. Silicide with from twenty-five to thirty per cent. silicon takes a fine polish, when it more or less resembles silver, although somewhat darker. The higher-grade silicides are the darker in color. The melting-point rises with the percentage of silicon. Silicide of twenty-six per cent. silicon can be melted in the crucible of a brass furnace, but takes a higher temperature

than brass. Silicide of thirty-two per cent. silicon cannot be melted that way. This latter can be melted in a crucible by using a good blast. The silicides containing more silicon could be successfully melted only in an electric furnace. These silicides should not be molten in a blast cupola. The silicon burns as easy or easier than the coke, and the molten metal will contain considerably less silicon than the original. A lot sent to a foundry and treated in a cupola lost five per cent. silicon out of twenty-seven per cent. If such partly oxidized metal is cast, it will often form a coating of a gelatinous silica in the mold. The latter is weakly transparent and elastic to quite a degree. I saw similar silica exhibited in the Carborundum Works at Niagara Falls.

Lower-grade silicides cast very well with sharp outlines and corners. When the amount of silicon is increased, the castings show a tendency to crack when cooling. The silicides of thirty-four to forty per cent. silicon usually form blow-holes besides cracking, when the castings cool. When the higher-grade silicides are cooled very slowly the tendency to crack is lessened. All these silicides are but slightly magnetic, and those with over thirty per cent. silicon are quite non-magnetic, which well shows that there is no free iron in the alloy. Their specific gravity falls with the percentage of silicon.

	Alloy of 12 per cent. silicon.	Alloy of 25 per cent. silicon.	Alloy of 46 per cent. silicon.
Specific gravity at 20° C.	6.8	6.36	4.85

These alloys conduct electricity easily, and are very hard. They are brittle, the more so when the percentage of silicon increases. They are unalterable in air or in water. Acids attack them very little, especially if they are not pulverized. Hydrofluoric acid forms an exception, for it easily dissolves all these alloys. Acid oxidizing agents attack these silicides less, the more silicon there is present. In order to obtain some idea of the rate at which the solubility in these agents varies with the percentage of silicon, three samples, *a*, *b*, and *c*, were ground so that they easily pass through a 100-mesh sieve. Two grams of each were treated with the reagent at summer temperature, side by side for two days, stirring frequently.

	50 cc. aqua regia $1HNO_3$ to 3HCl. Per cent. dissolved.	100 cc. saturated chlorine water. Per cent. dissolved.
a with 13 per cent. silicon	66.84	5.88
b " 25 " " "	9.86	....
c " 46 " " "	0.76	0.83

Toward alkalies the low grades are more resistant than the high grades. Fifty cc. of a twenty per cent. solution of caustic soda dissolved in two days from two grams of the ground silicide:

a with 13 per cent. silicon, 3.96 per cent. dissolved.
c " 46 " " " 9.68 " " "

Silicides made at Holcomb Rock contained:

	I. Per cent.	II. Per cent.
Silicon	26.35	36.56
Manganese	trace	0.31
Sulphur	trace	trace
Phosphorus	trace	trace
Titanium	....	0.94
Carbon	none	none

This alloy is thus shown to be of great purity.

Pieces of iron silicide are often found in calcium carbide, especially in carbide made from inferior materials. I found in such pieces from twelve to forty-five per cent. silicon. Any attempt to write chemical formulas for the material of such pieces must fail. They are mixtures of the same nature as those obtained in quantity.

MANUFACTURE.

The raw materials, which are commonly used in the works of the Willson Aluminum Co., are a good iron ore, river sand, and any kind of coke. The river sand contains some manganese and titanium. The quality of the iron ore can be materially reduced so long as the chief impurity is silica. In fact, for many reasons such an ore is preferable. After trying many fluxes, they were entirely abandoned, for they always reduce the output.

The materials are finely ground with the exception of the silica which should be of the size of coarse sand, on account of its volatilizing easily; and being very light, it is readily carried away by the draft of the furnace. At the temperature that exists in the electric furnace, the carbon monoxide does not act

as a reducing agent, and it is the solid coke particles that do the reducing. For this reason the mixing must be thorough and the ingredients must be finely ground.

We use at Holcomb Rock Works a continuous furnace of my own design. It is fed at the top and tapped at the bottom. These furnaces are run one week or in fact any length of time, and they can be cleaned and made ready for use again in a few hours. We make, so far, iron silicide in furnaces of only about 150 electrical horse-power, but by enlarging the furnace, we can easily use 1000 horse-power or more in one furnace, which will materially reduce the cost. Our furnaces give little dust and that only when they are opened. This is a great advantage, for the fine silica dust is very objectionable. I have seen this dust settle two inches deep all over the room from an open furnace.

During the operation the alloy runs to the bottom of the furnace, where it collects in a pool and is tapped at regular intervals. There is only little slag, if the materials are mixed in proper proportions. The metal which runs out is very free of enclosed slag. It comes out white and the tapping can be seen for quite a distance if windows or doors of the factory are left open. An excess of silica must always be taken, to make up for that which volatilizes. This excess must be materially increased when the higher-grade alloys are to be prepared. Since this volatilization of silica requires power, it follows that it takes more power in proportion to make a high-grade than to make a low-grade silicide. We use about twice as much power to make an alloy of thirty-five per cent. as to make one of twenty-five to twenty-seven per cent. The silicon in the former alloy is correspondingly more expensive.

USES.

On account of their great purity and small bulk these silicides are superior to those made in the blast-furnace, but they can only be used instead, where the character of the work admits of paying a larger price for the unit of silicon.

These alloys are very resistant against acid oxidizing agents and conduct electricity well. They are a cheap material for anodes for electrolysis in aqueous baths. The lower grades make nice correct castings. We exhibited, in Atlanta, in 1895,

some articles cast from a twenty-five per cent. alloy. These low-grade alloys can be used for making luxury articles, statuettes, etc. The metal when polished has a beautiful, and lasting luster. The higher grades and also the lower grades may perhaps be used instead of aluminum in the heating process of Goldschmidt. This process consists of mixing aluminum foil with some substance capable of yielding oxygen, and igniting the mixture at one point. The reaction between the aluminum and the oxygen, if started at one point, gradually proceeds through the whole mass and a heat is produced, which, in intensity, is second only to that of the electric arc. The silicon of the iron silicide may replace the aluminum, and can be made for a lower figure. These silicides are valuable abrasives, being very hard, and still easily crushed.

WILLSON ALUMINUM CO.,
HOLCOMB ROCK, VA.

[CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF MICHIGAN.]

PERHALIDES OF QUINOLINE.[1]

BY P. F. TROWBRIDGE.

Received December 13, 1898.

THE most of the work reported in this paper was completed in the spring of 1897. Publication was delayed because the author hoped soon to be able to complete the study of the halogen salts of quinoline, and the action of the halogens upon these salts and upon the base itself. Other duties have prevented this until it is deemed advisable to present the work in so far as ready, hoping to continue the research during the following year.

The halogen salts of quinoline have been known for a long time, yet only the chloride[2] seems to have been reported. No attempt was made to prepare this salt in crystalline form. For the experiments where the chloride was used it was assumed that it was formed by the addition of an excess of hydrochloric acid to the base. The results confirm this assumption.

An attempt was made to prepare the quinoline hydrobromide in pure condition. A mixture of the acid and base was warmed

[1] Continuation of previous paper. This JOURNAL, **19**, 558.

[2] Schiff: *Ann. Chem.* (Liebig), **131**, 112.

for some time on the water-bath. Upon cooling, nearly colorless needle-like crystals were obtained. As these were found to be exceedingly deliquescent, and the chief object in the preparation being the study of the further action of the halogens, the attempt at analysis was deferred. (This salt will be investigated later.)

Quinoline Hydriodide, $C_9H_7N.HI$.—Hydriodic acid (boiling-point 126°–127°) was added in slight excess to quinoline, and the mixture heated over a small flame in a flask provided with a reflux condenser. Upon cooling, the iodide separated out as yellow needle-shaped crystals. They were recrystallized from absolute alcohol. Melting-point 135°.

	Calculated for $C_9H_7N.HI$.	Found. I.	II.
Iodine	49.39	49.44	49.32

Quinoline Methyl Chloride, $C_9H_7N.CH_3Cl$, has been prepared[1] by heating quinoline, methyl alcohol, and concentrated hydrochloric acid to 160° for ten hours. Perfectly white crystals containing one molecule of water were obtained melting at 126°, and at 140° losing water and becoming deliquescent and rosy red. That used in the following experiments was prepared, without attempt at crystallization, by shaking a watery solution of quinoline methyl iodide with freshly precipitated silver chloride.

Quinoline Methyl Bromide, $C_9H_7N.CH_3Br$, was prepared by passing methyl bromide into quinoline. An abundance of colorless needle-like crystals were obtained. They were dried and used directly in the following experiments. They are readily soluble in water, alcohol, ether, and chloroform; slightly soluble in acetone, and almost insoluble in petroleum ether and benzene. Melting-point 70°. (Analytical data and other properties will be given in a later paper.)

Quinoline Methyl Iodide, $C_9H_7N.CH_3I$, has been reported by Williams[2] and La Coste.[3] For the following experiments it was prepared by heating quinoline and methyl iodide, on a water-bath, in a flask provided with a reflux condenser. They are sulphur-yellow crystals, soluble in water, alcohol, chloroform,

[1] Ostermayer: *Ber. d. chem. Ges.*, **18**, 593.
[2] *Jsb. d. Chem.*, *1856*, 534.
[3] *Ber. d. chem. Ges.*, **15**, 192.

and ether. Melting-point 72°, agreeing with Williams and LaCoste.

Quinoline Hydrobromide Tetrabromide, $C_9H_7N.HBr.Br_4$.—Hydrobromic acid was added, in slight excess, to quinoline, and the mixture then saturated with the vapor of pure bromine. A heavy, dark, oily layer separated, which soon solidified as a mass of dark red cubic crystals. They are soluble apparently without decomposition in water, ether, alcohol, and chloroform. Upon exposure to the air they gradually decompose, bromine being given off. Melting-point 39°.

	Calculated for $C_9H_7N.HBr.Br_4$.	Found. I.	II.
Total bromine	75.42	75.23	75.10
Bromine by thiosulphate	60.34	60.61	60.69

A portion of the crystals above described was exposed to the air until constant weight was obtained and no more bromine seemed to be evolved. The compound was then easily soluble in water, alcohol, ether, and chloroform. It crystallized from the last as beautiful red needles, apparently perfectly uniform in composition. Melting-point 88°. Analysis shows it to be a mixture of lower perbromides, and not a definite compound.

Quinoline Hydrobromide Dibromide, $C_9H_7N.HBr.Br_2$.—When an aqueous solution of quinoline hydrochloride was saturated with bromine, a heavy, red oil settled to the bottom, becoming a solid mass of red crystals as soon as separated from the supernatant liquid and exposed to the air. These crystals were dried rapidly between filter-papers and recrystallized from chloroform, fine red crystals melting at 98°–99°. A qualitative test showed entire absence of chlorine.

	Calculated for $C_9H_7N.HBr.Br_2$.	Found. I.	II.
Bromine by thiosulphate	43.20	43.07	43.10
Total bromine	64.80	64.29	63.98

Quinoline Methyl Bromide Dibromide, $C_9H_7N.CH_3Br.Br_2$.—Crystals of quinoline methyl bromide were dissolved in water and the solution saturated with bromine. At first a yellow precipitate formed, gradually changing to a heavy, red oil. When the oil was exposed to the air for the evaporation of the excess of bromine, it became a very hard, yellow, crystalline mass,

almost insoluble in water and ether, sparingly soluble in chloroform, and readily soluble in absolute alcohol, from which it crystallizes as yellow needles. Melting-point 108°.

	Calculated for $C_9H_7N.CH_3Br.Br_2$.	Found. I.	II.	III.
Bromine by thiosulphate	41.39	41.81	41.75	41.72
Total bromine	62.44	62.42	62.35	....

Quinoline Hydriodide Tetraiodide, $C_9H_7N.HI.I_4$.—Fifteen grams of iodine, dissolved in alcohol, were mixed with five grams of quinoline hydriodide, dissolved in water. Upon standing for some time a large bulk of black crystals was obtained. These were found to crystallize best from about sixty per cent. alcohol, from which solution they were obtained as lustrous black plates. Melting-point 76°.

	Calculated for $C_9H_7N.HI.I_4$.	Found. I.	II.
Iodine by thiosulphate	66.36	66.37	....
Total iodine	82.95	82.60	82.87

This same compound was formed when an alcoholic solution of iodine was added in excess to a solution of quinoline hydrobromide. The crystals first obtained were twice recrystallized from alcohol. Melting-point 76°. A qualitative test showed entire absence of bromine.

	Calculated for $C_9H_7N.HI.I_4$.	Found. I.	II.
Iodine by thiosulphate	66.36	66.31	66.33
Total iodine	82.95	82.51	....

Quinoline Methyl Iodide Tetraiodide, $C_9H_7N.CH_3I.I_4$.—An excess of an alcoholic solution of iodine was added to an aqueous solution of quinoline methyl iodide, $C_9H_7N.CH_3I$. Crystals began to form immediately and after a short time were separated from the mother-liquor, dried, and twice recrystallized from alcohol. Melting-point 70°. Analyses I and II are given below.

In another preparation, an alcoholic solution of iodine was added in excess to an aqueous solution of quinoline methyl chloride. Very dark crystals soon formed, which were dried and twice recrystallized from absolute alcohol. A qualitative test showed absence of chlorine, but the analytical results are a little high for the pure quinoline methyl iodide tetraiodide,— III and IV below.

In still another preparation, an alcoholic solution of iodine was added, in excess, to an aqueous solution of quinoline methyl bromide. Crystals began to form at once. After standing for some time the crystals were drained, dried, and recrystallized from alcohol, forming black-green crystals, melting at 70°. A qualitative test showed the absence of bromine,— V and VI below.

	Calculated for $C_9H_7N.CH_3I.I_4$.	Found. I.	II.	III.	IV.	V.	VI.
Iodine by thiosulphate	65.15	65.11	65.06	66.81	66.62	65.08	65.06
Total iodine	81.45	81.18	81.26	82.93	82.54	....	....

Quinoline Hydrochloride Bromide, $C_9H_7N.HCl.Br.$—Chlorine was passed for three hours into a mixture of quinoline and hydrobromic acid dissolved in an abundance of water. The solution became dark-colored and crystals were formed. Gradually the liquid became clear with a voluminous mass of yellow crystals in the bottom of the dish. These were washed with warm water and twice recrystallized from chloroform. They form fine yellow needles melting at 101°–102°.

	Calculated for $C_9H_7N.HCl.Br.$	Found. I.	II.
Halogens by thiosulphate	14.42	14.29	14.27
Total halogens	46.97	46.73	46.54

Quinoline Methyl Chloride Bromide, $C_9H_7N.CH_2Cl.Br.$—Quinoline methyl bromide was dissolved in water and saturated with chlorine. A yellow crystalline mass was formed, soluble in chloroform, from which it crystallized as yellow scales. Melting-point 112°. A qualitative test showed the presence of bromine.

	Calculated for $C_9H_7N.CH_2Cl.Br.$	Found. I.	II.
Halogens by thiosulphate	11.35	11.10	11.03
Total halogens	32.94	32.17	32.11

Quinoline Hydrochloride Iodochloride, $C_9H_7N.HCl.ICl.$—Quinoline hydriodide dissolved in water, was warmed on the water-bath and then saturated with chlorine. The solution became dark at first, as if from precipitated iodine, then the dark color gradually disappeared with the formation of yellow crystals. These are sparingly soluble in chloroform, but long yellow prismatic crystals were obtained by partial evaporation of the chlo-

roform solution and then setting aside, loosely covered, in a cool place. Melting-point 112°.

	Calculated for $C_9H_7N.HCl.ICl$.	Found. I.	II.
Halogens by thiosulphate	21.61	21.75	21.64
Total halogens	60.27	60.04	59.70

Quinoline Methyl Chloride Iodochloride, $C_9H_7N.CH_3Cl.ICl$.—A watery solution of quinoline methyl iodide was heated on the water-bath and saturated with chlorine. The clear solution rapidly assumed a very dark brown color, gradually changing to a clear solution and a yellow precipitate. The precipitate was collected, dried, and recrystallized from chloroform. Fine yellow crystals were obtained.

	Calculated for $C_9H_7N.CH_3Cl.ICl$.	Found. I.	II.
Halogens by thiosulphate	20.73	20.60	20.58
Total halogens	57.80	57.64	57.48

Quinoline Hydrobromide Iodobromide, $C_9H_7N.HBr.IBr$.—Quinoline hydriodide was dissolved in water and saturated with bromine. A dark oil, containing crystals, soon settled to the bottom of the liquid. The oily and crystalline mass was carefully separated from the supernatant liquid, and warmed upon the water-bath to drive off excess of bromine. A red crystalline mass was obtained moderately soluble in absolute alcohol, from which solution it crystallizes nicely after partial evaporation. Melting-point 109°.

	Calculated for $C_9H_7N.HBr.IBr$.	I.	Found. II.	III.
Halogens by thiosulphate	38.36	38.40	38.31	38.34
Total halogens	68.77	68.52	68.40	....

Quinoline Methyl Bromide Iodobromide, $C_9H_7N.CH_3Br.IBr$.—Heavy, dark red oil is formed upon saturating a watery solution of quinoline methyl iodide with bromine. Upon exposing the oil to the air for the evaporation of the excess of bromine, a mass of reddish crystals was obtained. These crystallized from absolute alcohol as yellow plates containing iodine. Melting-point 108°.

	Calculated for $C_9H_7N.CH_3Br.IBr$.	I.	Found. II.	III.
Halogens by thiosulphate	37.11	37.66	37.32	37.24
Total halogens	66.51	66.40	66.37	....

SUMMARY.

The action of bromine upon quinoline methyl chloride has not been studied, nor the action of the halogens upon the ethyl halides of quinoline. These will be reported later. Iodine completely displaces chlorine from quinoline hydrochloride, but in all cases a tarry-like mass was obtained, which could not be purified for analysis.

The general reactions with quinoline are very similar to those with pyridine[1]. No perchlorides of the normal chlorides are formed. Chlorine seems to displace bromine and iodine from the normal position, and then, with the iodocompounds, to combine with the displaced halogen, forming iodochlorides of the normal chlorides. With the bromides there is but one atom of perhalogen, thus giving other instances of a probable bivalent halogen[2]; *i.e.*,

$$C_9H_7N\begin{matrix}R\\ \diagup\\ \diagdown\\ Cl{=}Br\end{matrix} \quad \text{or} \quad C_9H_7N\begin{matrix}R\\ \diagup\\ \diagdown\\ Cl{-}Br.\end{matrix}$$

Bromine displaces chlorine completely, forming perbromides of the normal bromides. It displaces iodine from the normal position and then combines with the displaced iodine to form an iodobromide of a normal bromide. Iodine displaces both chlorine and bromine from the normal position forming periodides of the normal iodides.

The action of the halogens upon quinoline has been studied by Grimaux,[3] Claus and Istel,[4] Ostermayer,[5] and Dittmar[6]; but none of these give the action of reducing agents as showing the probable relation of the halogen atoms. It is purposed to take up this study in the near future.

I wish to express my thanks to Professor A. B. Prescott, in whose laboratory and under whose general supervision the work has progressed; also to Mr. John D. Wombacher, for his assistance in the laboratory at Ann Arbor.

MARBURG, GERMANY, November 24, 1898.

1 This Journal, 19, 558.
2 *Ibid.*, 19, 322.
3 *Bull. Soc. Chim.*, 38, 124
4 *Ibid.*, 18, 600.
5 *Ber. d. chem. Ges.*, 15, 824.
6 *Ibid.*, 18, 1613.

REVIEW.

THIRD INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

[Held in Vienna, July 27–August 4, 1898.]

Dr. C. E. Munroe, President of the American Chemical Society:

SIR: I have the honor to submit the following report of my observations as a delegate of the American Chemical Society to the Third International Congress of Applied Chemistry, held in Vienna, July 27 to August 4, 1898.

The president of honor of the congress was Dr. Alexander Bauer, K. K. Hofrath and professor of chemistry in the Imperial Technical High School of Vienna.

The acting president was Dr. Hugo Ritter von Perger, Regierungsrath and professor in the Imperial Technical High School.

The vice-presidents were chosen from the several sections in proportion to their membership. Nearly all the vice-presidents were selected from among the delegates of foreign nations. Our society was represented among the vice-presidents by Prof. W. B. Rising, of the University of California; Dr. F. G. Wiechmann, chief chemist of the American Sugar Refining Co.; and Dr. H. W. Wiley, chief chemist of the U. S. Department of Agriculture. Among other vice-presidents whose names are well known, may be mentioned Professors Fischer, Buchner, Herzfeld, Claassen, Vogel, and von Lippman, of Germany; Moissan, Fernbach, Dupont, and Lindet, of France; Lobry de Bruyn, of Holland; and Piutti and Verdrödi, of Italy. The members of the Austro-Hungarian Cabinet were also made presidents of honor.

A preliminary meeting of the committees and an informal reception to visiting members took place on the evening of July 27th in the Cursalon of the City Park. A concert by a military band and abundant refreshments were offered to the members of the congress on this occasion.

On the 28th of July the general opening of the congress took place in the Aula of the Vienna University.

The opening discourse was given by Prof. Dr. von Perger, as follows:

"Most esteemed gentlemen: As chosen chairman of this select assembly, I have the great honor of opening the Third International Congress of Applied Chemistry. Permit me, before I fulfil this pleasant duty, to express the wish that this association of the most prominent men of science, honored as it is by the presence of illustrious representatives of various governments, may accomplish the grand purpose which has created it in fully as brilliant a manner as at Brussels and Paris, so that it

will justify the intentions of those who see in the personal intercourse of the representatives of applied chemistry, in this international association, an important means of furthering common interests.

" Cooperation in work has, as a look into the past will show, always accomplished great ends. I am certain that I need not enumerate examples as proof of this.

" The great thoughts which have irresistibly guided future progress, the thousands of discoveries and inventions which have rendered possible the development of chemical technics, the tedious labors in the laboratory and factory, are as an open book to you who are cooperating in this grand work directed toward the betterment of all, for they represent at least in part your own experiences. A comparison of the present with the past fully guarantees the constantly increasing importance of technical knowledge, and correspondingly the growing reputation of its representatives. It enables us to determine the paths in which our knowledge of material growth proceeds with regularly increasing rapidity, and even now permits us to recognize great problems whose solution is approaching.

"While in the field of the chemical technology of inorganic compounds the raw materials used on the large scale have remained the same, there being added only the preparation of the carbides and rare earths, the methods of production have been amended with great success with reference to rational management and control.

" The application of electrical energy has caused and will, in the future, result in important changes.

" The raw materials of the chemical technology of organic bodies have in numerous branches of the latter hitherto remained the products of the processes of life, and progress has been confined for the most part to a further development of methods, both analytical and practical, apart from the notable improvements in the fermentation industries.

" The triumphs of synthesis have been mostly identified with the chemistry of coal tar and its constituents. They have not only caused a complete revolution in the textile industries, but have also accomplished much in the preparation of valuable medicinal compounds.

" The theory of the constitution of aromatic compounds, which have proved of such value in the technology of dyeing, has not been without influence on other branches of research. The gulf, which existed for many years between compounds of the ' aliphatic' and ' aromatic' series, has been bridged by the discovery of the ' hydrocyclic' compounds.

" The unitarian system represents fully as great an advance as the synthesis of urea (1828) by Wöhler, which marked an

epoch in the history of chemistry in that it once for all overthrew the doctrine that life was an essential to the production of organic compounds.

"The separation of optically inactive substances into other substances which are dextro- and laevo-rotatory, which disproved the hypothesis that the rotatory power of compounds containing carbon is a characteristic proof of their derivation from organized bodies, was but a further result of the knowledge previously acquired.

"Just as Chevreul at the beginning of this century explained the constitution of the fats by his notable investigations on the process of saponification, the results of which have never been questioned, so has Emil Fischer ushered in a new epoch by his illustrious work on the synthesis of the carbohydrates.

"The well-known hydrolysis of starch, the separation of complex molecular compounds into simpler compounds, whose constitution has been determined, the first synthesis of a 'glucoside' by Emil Fischer, the recent experiments of Marchlewsky on the synthesis of sucrose from artificially produced 'levulose' and 'dextrose', all lead directly to the desire to find 'Reversion-reactions,' which will enable us to build up compounds of high molecular weight, whose molecular complex has been approximately determined by Raoult's method.

"The feasibility of such syntheses being assumed, we more closely approach a solution of the question of organization, and the gap which exists between this and the so-called inorganic compounds will be bridged over similarly to that which formerly separated the fatty and aromatic series.

"The reversion-reactions will secure the synthesis of substances, whose production in this manner will be of great economic value, just as the synthesis of alizarin by Graebe and Liebermann has, and as the preparation of synthetic indigo will become, the latter acquiring more and more practical importance every day.

"The outlook with reference to the results of our present knowledge is elevating; it indicates the satisfactory solution of questions which interest not only the chemist, but the national economist, and possibly the philosopher.

"Encouraged by previous successes and having absolute faith in the unchangeable advance of knowledge, we look into the approaching century with the confidence born of successful investigation, the unity of being, the exploration of the synthesis of organic compounds, those complex compounds, whose synthesis will lead to the secret of the organization of life.

"With this view of the future I have ventured to address this most distinguished assembly and with these modest words I may be permitted to open the Third International Congress."

Dr. Bauer addressed the congress briefly after Dr. von Perger had finished. He said:

"Gentlemen: As honorary president of the committee of organization for this meeting I have the great honor to bid you a cordial welcome, and I take advantage of this occasion to express our satisfaction at seeing so many illustrious members in our midst.

"Our program is rather a large one and involves a great many and various subjects. I think the most satisfactory part of it will be shown in the fact that there is always an agreement in human labor between practical work and theoretical investigation.

"If chemistry has not to be the servant of any one art, as Robert Boyle said two hundred years ago, the chemistry of to-day allows us to serve the arts and at the same time and in the same way to devote ourselves to the study of the highest problems of science.

"In the name of the Austrian chemists I thank most sincerely those who have shown their interest in the success of this congress by personally appearing here; also those who have become members of the congress in all parts of the world, but who have been prevented from attending its meetings. If we shall succeed in making this congress a success, it will be due chiefly to the important position which science and industry have taken in our fatherland.

"For this we thank first of all the wise care and thoughtfulness of our most gracious Emperor, and we are most happy, gentlemen, to have you here on the occasion of the celebration of the fiftieth year of his reign. I invite you, therefore, to join with me in crying, 'His Majesty, our most gracious Emperor and Lord, his royal and Imperial Catholic Majesty, Franz Josef First, er lebe hoch! und dreimal hoch!'"

All the members arose and joined in the cheers, and thereafter the following telegram was sent to the Emperor:

"*To His Excellency, Count Paar,*

"*Chief Adjutant of His Majesty, Ischl.*

"The Third International Congress of Applied Chemistry, now sitting in Vienna, begs your Excellency to present to His Majesty in the name of the Congress the request that His Supreme Majesty will most graciously accept the homage and the most cordial wishes of the Congress on this jubilee year.

"For the Congress: RITTER VON PERGER."

To this telegram the following reply was received:

"In accordance with the imperial command I have the honor to return to the honored chairman of the Third International Congress of Applied Chemistry the thanks of the Emperor for

the telegram of homage addressed to His Imperial and Royal Apostolic Majesty.

"KUENBURG.

"Ischl, July 29, 1898. "Acting for Count Paar."

Dr. Strohmer, the general secretary of the Congress, then presented his preliminary report, in which the organization of the work of the congress was discussed. Committees on organization were formed by the central committee, not only in Austria, but also in other countries. The Austrian committee consisted of nearly 200 persons, of whom 153 were inhabitants of Vienna. 12,000 circulars were printed in German, French, and English, and sent to chemists in all parts of the world. Notices of the meeting were printed in more than 200 scientific journals. Special invitations were sent to more than 600 investigators in all countries to prepare papers, and the hundreds of responses received show how generally these invitations were accepted. In closing, Prof. Ströhmer said:

"In this short report I hope I have shown that the organization committee of the Third International Congress of Applied Chemistry has not in earnestness and industry fallen behind the Paris committee for the second congress, and I further hope, gentlemen, that you will find that we have laid a sufficient foundation for your work while here."

SCIENTIFIC ADDRESS BEFORE THE WHOLE CONGRESS.

Only one scientific address was delivered before the general session of the congress; *viz.*, "Fermentation without Cells," by Prof. Buchner. The speaker stated that the results he had obtained, and which he would proceed to demonstrate, showed that the old notion which supposed that fermentation could only take place under the influence of a living cell, like that of yeast, for example, was evidently erroneous. Cells capable of effecting fermentation probably acted through the production of another body, a residue of cell vitality, and it was this body that was the active principle. The method of preparing yeast liquor containing no yeast cells was described in detail. Fresh Munich beer yeast is deprived of water by a pressure of fifty atmospheres, and is then mixed with an equal weight of quartz sand and a fifth of its weight of kieselguhr, and the whole pulverized. The process is continued until the pulverized mass begins to stick together and on examination with the microscope shows that at that time about forty per cent. of the yeast cells are crushed. The mass is placed on a cloth and gradually subjected to a pressure of 500 atmospheres in a hydraulic press. The cake is removed, moistened with water, and again pressed.

From one kilo of yeast about 500 cc. of juice are obtained by the above treatment, of which only about 140 cc. should be due to the added water. The expressed yeast juice drops from the press into a folded filter, and the filtrate is received in a flask cooled with ice-water. Nearly all the yeast cells are destroyed by the pressure, the microscope showing only about four per cent. intact. The others are seen to be only empty walls, their contents having all been expressed. In the yeast juice certain enzymes are found; *viz.*, invertose, oxydases, and proteolytic ferments. The yeast juice is capable of fermenting sucrose, maltose, *d*-galactose, *d*-fructose, *l*-arabinose, and mannose. It does not act on lactose. *d*-Galactose and glycogen are fermented with difficulty.

It appears, therefore, that fermentation is not a physiological process, or, in other words, a complex vital act. It depends rather on an enzyme-like body resembling zymose, which is produced only in the organisms of living cells like those of yeast. Numerous experiments, showing the fermentative action of the yeast juice, were made during the progress of the lecture.

THE WORK OF THE SECTIONS.

The congress, after the opening session and the address of Prof. Buchner, separated into sections, of which twelve were organized for work. On account of the large number of papers offered in some of the sections, it was found necessary to organize a number of subsections. The final arrangement for sectional work was as follows:

Sec. I. General analytical chemistry and apparatus.
" *II.* Medical, pharmaceutical, and food chemistry.
Subsection A. Pharmaceutical chemistry.
" B. Food chemistry.
" C. Medical chemistry.
" *III.* Agricultural chemistry.
" *IV.* Chemistry of the sugar industry, starch and grape sugar.
" *V.* Chemistry of fermentation.
Subsection A. Beer brewing and malt manufacture.
" B. Alcohol and compressed yeast industry.
" *VI.* Chemistry of wine.
" *VII.* Chemical industries of inorganic materials.
" *VIII.* Metallurgy, mining chemistry, and explosives.
" *IX.* Chemical industries of organic bodies.
Subsection A. Coal-tars and textile dyes.
" B. " " " " "
" C. Chemistry of fats, oils, and lubricants.

Sec. IX. Subsection D. Paper and cellulose.
" E. Tanning and glue.
" *X.* Chemistry of printing (lithograph, photograph, etc.).
" *XI.* Didactic chemistry.
" *XII.* Electrochemistry.

It would not be possible to give an extract or even the titles of the hundreds of papers read before the sections. Unfortunately, no complete programs of the papers read before each section were printed, and members could only find out what was going on by going from section to section. Only brief abstracts, and of these only of the most important papers, were printed during the congress. A rather comprehensive résumé of the papers presented is appearing in the *Oesterreichische Chemiker-Zeitung*, in the *Chemiker-Zeitung* edited by Dr. Krause at Cöthen, and in the *Wockenschrift des Central-vereins für Rübenzucker Industrie in der Oesterr-Ungarische Monarchie.* Practically all the papers will appear in full, in the various chemical journals, and in the printed proceedings of the Congress.

Some of the more important papers presented in the various sections are as follows:

Sec. I.—1. Estimation of Phosphoric Acid, by Prof. H. Lasne.

2. Choice of Atomic Weights, by Dr. Bersch.

3. Proposals for the Uniform Use of Indicators in Volumetric Analysis, by Dr. Paul Degener.

4. Final action on the resolutions of the Second International Congress relating to the construction and introduction of uniform areometers, burettes, etc.

Sec. II.—1. Testing Butter for Foreign Fats and Refractometric Milk Analysis, by Dr. Wollny. In these papers Dr. Wollny described the use of his refractometer for determining the fat in the ether extract of milk obtained in much the same way as in the old Soxhlet method of determining the fat by the density of the ether solution. The method is very rapid and reasonably accurate, and especially where small quantities of fat are concerned, as in the case of skim milk.

2. Examination of Lard, by Dr. Raumer.

3. Examination of Ethereal Oils with the Polariscope, by Dr. Duyk.

4. Determination of the Purity and Activity of Serum, by the French Committee.

5. Determination of Gluten in Flours, by M. Fleurent.

6. Changes of Chlorine-holding Materials in the Organism, by Dr. Gross.

7. Analysis of Potable Waters, by M. Durand.

8. Is It Possible to Detect Pure Brandy by Chemical Means? by Dr. Werber.

9. What is the Limit of Copper Content in Preserved Vegetables, etc., by Dr. Baum.

10. Synthesis of Protein, by Dr. Leon Lilienfeld.

Sec. III.—1. Plants Suitable for Cultivation on Forest Domains, by Arthur Thezarie.

2. Culture of Peaty Lands, by Dr. B. Tacke.

3. Rational Treatment of Stall Manures in Order to Avoid Loss of Nitrogen, by Dr. Schneidewind.

4. The Chemical Composition of Indian Corn and Its Important Products, by Dr. H. W. Wiley.

5. Feeding Cattle with Molasses, by M. Vivier.

6. Unification of Methods for the Analysis of Chemical Manures, by Prof. Angelo Menozzi.

7. Determination of Phosphorus Pentoxide as a Control Method, by Dr. Ritter von Grueber.

Sec. IV.—1. The Role of Pentosans in Sugar Manufacture, by Dr. A. Stift.

2. Influence of Saccharose on the Determination of Pentosans, by Karl Andrlik.

3. Influence of Temperature on the Specific Rotatory Power of Sucrose, by H. W. Wiley.

4. New Processes of Sugar Manufacture and Increased Output, by Dr. A. Herzfeld.

5. The Electrolytic Estimation of Sugar, by J. Formanck.

6. Crystallization of Amorphous Sucrose, by F. G. Wiechmann.

7. Greek Sugar Beets, by Prof. A. Christomonas.

8. The Chemical Nature of Caramel, by N. Fradniss.

9. The Viscosity of Sirup, by Dr. A. Classen.

10. International Methods of Determining the Quality of Sugar-beet Seed, by G. Pammer.

Sec. V.—1. The Diastatic Power of Mushrooms, by Dr. Jean Effront.

2. International Agreement of Methods of Malt Examination, by Prof. L. Aubry.

3. The Steps in the Hydrolysis of Starch, by Prof. Dr. Lintner.

4. The Pasteurization of Beer in Bottles and Barrels, by Prof. Caro.

5. Continuous Rectification, by Drs. Barbet and Fernbach.

6. Estimation of Aldehydes, by Prof. Istrati.

7. Invert Sugar Estimation, by Dr. G. Bruhus.

Sec. VI.—1. Methods for the Chemical Examination of Wine, report by Drs. Barth, Bain, Kruger, and Haas.

2. Influence of Climatic Conditions on the Wine, by Dr. Radulescu, Prof. Dr. Hilger, and Dr. Roesler.

3. Influence of Animal and Plant Parasites on the Character of the Wine, by Prof. Barth.

4. Influence of Fertilization on the Character of the Wine, by Prof. Barth.

5. Influence of the Different Ferments on the Character of the Wine, by Prof. Worthmann.

6. Methods of Controlling the Progress of Fermentation, by Dr. Joseph Bersch and W. Seifert.

7. Influence of the Electric Current on the Ripening of Wine, by Drs. Barth and Kreps.

Sec. VII.—1. The Present Condition of the Petroleum Industry, by Prof. Zalozucki.

2. The Flashing-point of Petroleum, by C. A. Lobry de Bruyn.

3. Acetylene Generators and Acetylene Burners, by Dr. N. Caro.

4. The Industrial Manufacture of Ammonium Nitrate, by M. Truchot.

5. Chemical Processes in the Burning and Slaking of Lime, by Prof. Dr. A. Herzfeld.

Sec. VIII.—1. The Manufacture of By-products from Iron Ores, by Emil Hulz.

2. International Agreement with Reference to the Handling and Transport of Explosives, by Phillip Hess and Julius Ephriam.

3. Theory of Safety Explosives, by Julius Ephriam.

4. Chemical and Microscopic Examination of Gunpowder, by A. Croquert.

5. A New Process of Producing Water-gas, by George Hangsdorf.

6. Some New Methods of Steel Analysis, by L. Verrier.

7. New Methods of Electrical Estimation of Zinc in Ores, by Dr. Henry Pawck.

Sec. IX.—1. The Present Condition of the Chemistry of Coal-tars, by Dr. P. Friedländer.

2. International Adoption of the Baumé Scale for the Determination of Specific Gravity, by Prof. Wolfbauer.

3. The Analysis of Resins, by Dr. Carl Dietrich.

4. The Technical Analysis of Bone Fats, by Dr. Slenkoff.

5. The Chemistry of Paper-making, by Dr. Kellner.

6. The Analysis of Tanning Substances, by Prof. Müller.

7. Study of the Different Kinds of Glues, by A. Cronquist.

Sec. X.—1. Influence of the Chemical Composition of Glass on the Character of Photographic Lenses, by Dr. A. Miethe.

2. Results of Experience in Photographing with Artificial Lights (Magnesium, Aluminum, Auer, Acetylene, etc.), by Henry Kessler.

3. Methods for Determining the Precious Metals in Photographic Baths, by Prof. A. Lainer.

4. Best Methods of Recovering the Precious Metals from Photographic Residues, by Prof. A. Lainer.

5. Most Sensitive Paper for the Less Refracted Spectral Rays, by Dr. M. Andresen.

Sec. XI.—1. The Education and Qualifications of Official Food Chemists, by Dr. Kaiser.

2. The Requirements for Official Technical Chemical Service in Austria-Hungary, by Dr. N. Bomburger.

Sec. XII.—1. Preparation and Properties of Metallic Calcium, by Prof. H. Moissan.

2. Novelties in Eletrochemical Technics, by Dr. Kellner.

3. Uniform Conditions in Electrochemical Work, by Dr. G. Vortmann.

REMARKS ON PAPERS.

In addition to the papers already mentioned, those by Moissan and Lilienfeld attracted general attention. American chemists are so familiar with Moissan's work that it would be a work of supererogation to refer to it here at any length. The methods of preparing metallic calcium were described, samples of the metal shown, and its physical and chemical properties illustrated.

ARTIFICIAL ALBUMEN.

The synthesis of a peptone or peptonoid by Lilienfeld marks a distinct step forward in synthetic work, in the field already partly explored by Grimaux, Pickering, Williamson, and others. We can now speak, however, only of its centesimal composition. The state of its molecular condensation and atom position can only be determined by securing large quantities of the product and submitting it to chemical and digestive studies. It is probable that, as in the case of sugars, the artificial peptone will lack the vital element. In other words, while the chemist has succeeded in building molecules which resemble, in every outward respect, those built up by nature, they are uniformly dead, without cell functions or cell activity. The details of this important scientific work must be awaited before a final judgment, in regard to its far-reaching importance, can be formulated.

The synthesis of peptone is effected by the condensation of phenol with glycocoll with the help of phosphoroxychlorid. A hydrochlorate of peptone results, which gives all the characteristic reactions of protein. By conversion into sulphate and the decomposition of the latter, the free peptone is obtained which, it is claimed by Lilienfeld, is similar both in chemical and physiological properties to the natural product.

It is evident from the method of preparation that the product contained no sulphur, since the only sulphur-containing ingredient used was sulphuric acid, and this could not possibly enter into the organic preparation. Granting that a peptonoid body

was produced, the synthesis of a true proteid, which should contain sulphur, is still undemonstrated.

The color reactions which are supposed to be characteristic of protein must not be relied on too surely. They are probably due to decomposition, and not to the action of the molecule as a whole. It is stated by Pickering that a mixture of tyrosin, indol, and biuret will give all the reactions characteristic of a proteid. If the prospects of artificial food depended on these so-called synthetic products, the vocation of the geoponist would be assured for many millions of years to come.

PAPERS BY AMERICAN CHEMISTS.

There were only a few papers presented by American chemists. Dr. Wiechmann read a paper on "The Crystallization of Amorphous Saccharose." It was shown that the presence of invert sugar, the intensity of light, and, in an indirect manner, the presence of certain inorganic salts, influenced the beginning and progress of crystallization. As a result of the investigation, it was established:

1. That the crystallization of amorphous sucrose is to be ascribed to the presence of crystals of ordinary sucrose which are contained in the melt.

2. The change of amorphous into crystallizable sucrose is hindered by the presence of invert sugar, and the retardation is proportional to the amount present.

3. Inorganic salts and certain other bodies do not, of themselves, tend to produce crystallization of the amorphous sucrose.

4. Alkaline salts which tend to prevent the inversion of sucrose, and thus keep the proportion of invert sugar down, favor a condition which results in the more rapid crystallization of the amorphous sucrose.

5. Light, or the energy produced thereby, favors the crystallization.

In introducing the paper the author referred to his previous publication on the subject, in which the methods of preparing amorphous sucrose were described.

Dr. Wyatt's paper on "American Methods of Fermentation" was listened to with great interest, especially by those who supposed that no information on this theme could come from America.

Dr. Wyatt divided the subject of fermentation into two classes; *viz.*, sugars readily fermentable, and sugars and non-sugars which do not readily ferment or which are necessary to give roundness or mellowness to beer. If the sugars of these two classes really exist as separate compounds, they may be regarded as malto-dextrin. In addition to these the brewer must also consider the dextrins which are quite unfermentable, and yet which

give body to beer. The free acidity of beers is due chiefly to phosphoric and lactic acids. A barrel of beer of ordinary composition weighs 171 pounds and contains 35.4 pounds of solid matter. The total free acid estimated, as lactic acid in a barrel of beer is ⁹.406 of a pound, or 0.15 per cent. Normal beer yeasts require slightly acid pabulum, while the foreign organisms found in breweries, and which cause so much trouble, flourish best in neutral or alkaline fluids. Acidity also causes various types of albumens to remain in solution in the beers. The poor flavor characteristic of pasteurized beers is mainly attributable to their lack of acidity. The mineral matters in beer are chiefly phosphates, together with some sulphates or chlorides. All the acids are chiefly in combination with potassium and lime. The nitrogenous bodies which are in solution in beer belong to the classes of albumoses, peptones, and amids. As the temperature of beer decreases, portions of these bodies tend to be precipitated, and thus a beer which is brilliant at a temperature of 50° will become cloudy if the temperature is decreased. It is important, therefore, in the storage of beers, that they be kept at a low temperature long enough to secure a complete precipitation of these bodies. The necessity for a longer cold storage of the beers is not easily established, and the prevailing opinion that they should be kept for a much longer period is probably erroneous.

Dr. Wiley's paper on "The Influence of Temperature on the Specific Rotation of Sucrose" was discussed at length by Drs. Herzfeld and von Lippmann. The methods of research employed were described in detail, and all the disturbing forces discussed and the degree of disturbance determined for each. It was shown that on using a compensating quartz wedge to determine the degree of the rotation the temperature influenced the results obtained in the following ways:

1. It causes a change in the rotatory power of the quartz wedge, this power increasing with a rising temperature. From this it follows that a less thickness of the wedge is necessary to produce a given compensation at a high temperature.

2. The volume of the flask increases with a rising temperature, and hence the volume of the solution is greater as the temperature rises.

3. The weight of water in a given volume decreases as the temperature rises, and hence arise differences in the concentration of the solution.

4. The length of the observation tube increases with a rising temperature.

5. The degree of concentration of the solution affects its specific rotatory power.

6. Any variations in specific rotatory power, which are observed after introducing the correction for the disturbances above noted, must be due to direct effect of the change of temperature on the specific rotatory power.

7. Making the corrections noted, it was found that the specific rotatory power of pure sucrose at different temperatures is as follows:

$$\text{At } 4^\circ \; a_D = 66.653^\circ.$$
$$\text{“ } 17.5^\circ \text{ “ } = 66.547^\circ.$$
$$\text{“ } 40^\circ \text{ “ } = 66.340^\circ.$$

In his paper on “The Composition of Indian Corn and Its Chief Products,” Dr. Wiley discussed the problem of the economic use of maize as food for man and beast. The composition of all parts of the plant was given from the latest analyses, chiefly those of the Chemical Division of the Department of Agriculture. Statistics were given, showing the magnitude and value of the crop in the United States. The extended use of maize as human food in the United States was referred to, and especially the fact that the hard labor of the southern part of the country was done chiefly on a diet of maize bread.

The utilization of the maize stalks as a cattle food, and of the pith as a packing for coffer-dams of battleships and for other purposes, was discussed. The employment of maize as a source of starch, glucose, alcohol, and whisky was described. The chief object of the paper was to call the attention of European scientists to the value of maize for the purposes mentioned, and to show the groundlessness of the prevalent notion in Europe that it is unfit for European consumption. At the close of the paper the prevailing opinion in Europe concerning maize was pointedly brought out by the following question: “Is it true that maize is actually used in your country for bread-making without admixture with the flour of some other cereal?”

The poor opinion which Europeans have of the character of maize bread arises partly from ignorance, and partly from the fact that European maize lacks that delicacy of flavor and richness of taste which belong to the American article. Further than this, it may be mentioned that maize bears, very poorly, transportation across the sea, and therefore the imported maize or maize flour often makes a very unpalatable bread. A method of transporting the maize and preserving it entirely fresh at the same time will do much to remove the unreasonable prejudice prevalent in Europe against maize as a human food.

ATTENDANCE.

According to the report of the general secretary, Dr. Ströhmer, read at the final general session, the membership of the congress exceeded 1,700. The actual attendance, however, fell

far short of this number. A great many chemists who took membership tickets did not attend the congress. No list of members actually present was published, and therefore only an estimate not very reliable can be made. Such an estimate would place the actual members in attendance at about 800.

The organizers of this congress should have attended a meeting of the American Association for the Advancement of Science before the opening of the Vienna congress. There was no official program of papers nor list of members published. This part of the work was committed to the publishers of the *Oesterreichische Chemiker-Zeitung*. The result was that no one could find out, except by an accidental meeting, who were in actual attendance. No attempt was made to give the city address of those present, and therefore, except by the aid of the police, the search for a friend was hopeless. These facts are not stated as a carping criticism of the management. On the contrary, the local committee displayed the most commendable zeal in its efforts to entertain and oblige visiting members. About thirty American chemists had taken membership tickets in the congress, but only the following Americans were actually present at the meetings: Prof. W. B. Rising, delegate from the University of California; Dr. J. M. Flint, delegate from the Navy Department; Dr. H. W. Wiley, delegate from the Department of State, the Department of Agriculture, and from the American Chemical Society; Dr. Francis Wyatt, of New York; Dr. F. G. Wiechmann, of New York; Mr. Waldron Shapleigh and Mr. H. C. Watts, of Philadelphia; and Mr. M. Ikuta, of the University of Chicago.

Of other foreign countries, France had the largest representation, the French group consisting of about sixty persons. The Germans, strange to say, were no more numerous than the French. Next in numbers came the Russian contingent, while from the other continental nations only a few representatives were present. As was the case at Paris, England had no representative. The abstention of the English chemists from these congresses is somewhat surprising. Greece was not without a delegate, and it seems somewhat strange to hear a fellow countryman of Homer and Socrates discussing the relative merits of the several varieties of sugar-beets.

PLACE OF NEXT MEETING.

There was practically no opposition to the invitation received from the French delegates to hold the fourth congress in Paris. The Germans, however, have a tacit expression of preference for the congress to go to Berlin in 1902. Since all the world will make a pilgrimage to Paris in 1900, it was almost the unanimous opinion of the delegates that it would not be wise to

attempt to hold the next meeting in any other city. In view of the fact that there will doubtless be a large attendance of American chemists at Paris in 1900, the suggestion of the propriety of arranging for their entertainment may not be amiss. If 300 members, or even a less number, of the society propose to attend this congress, it would be conducive to economy and comfort to arrange for quarters in advance. It is therefore suggested that those proposing to attend take concerted action for the purpose of securing proper accommodations. A Congress-Chemical-Exposition Club would, if strong enough in numbers, be able to secure great economy in transportation and entertainment.

PERMANENT COMMITTEE.

Heretofore each congress has been an independent body with a life of its own which has expired with the final adjournment. It was deemed wise at Vienna to make the congress a continuous body, remaining under the constant control of delegates from all represented countries. Dr. Ritter von Grueber proposed, therefore, at the final session, that such a committee be formed, and this proposal was unanimously approved. Some of the members of the committee appointed at this session are named below :

President : Prof. Moissan, of Paris ; America : Doremus, Rising, Wiechmann, and Wiley ; Austria–Hungary : Meissl, Ströhmer, and von Perger ; Belgium : Masson ; Denmark : Kjeldahl ; England : Procter ; France : Berthelot, Déhérain, Dupont, Lasne, Lindet, and Pellet ; Germany : Delbrück, Fischer, Herzfeld, and Von Grueber ; Italy : Piutti and Verdrödi.

The representatives from other countries will be appointed later by the president of the committee on suggestions from leading chemists and associations of the countries interested. The committee also has power to add to its members in the countries above named.

SECOND MEETING OF THE INTERNATIONAL COMMISSION ON UNIFORM METHODS OF SUGAR ANALYSIS.

This meeting was held on July 31st, in the hall of the Central Association of the Beet-sugar Union of the Austro-Hungarian Monarchy. The chairman of the committee, Prof. Dr. Herzfeld, presided. In all about thirty members were present, among whom may be mentioned Messrs. Dupont and Weisberg, of France ; Ströhmer and Stift, of Austria ; Weinstein, Thiele, Müller, and Huck, of Germany ; Van Ekenstein, of Holland ; Nasini, of Italy ; and Wiechmann and Wiley, of America.

The chairman of the committee gave a detailed account of the

origin of the committee and its first meeting, which was held in Hamburg. He noted with pleasure that in almost all countries which are interested in the sugar industry a desire had been shown to take part in the labors of the commission. Only English chemists have refrained from taking any part in the work of the committee.

Afterwards the chairman gave a detailed account of the international testing of quartz plates. Twenty different plates had been sent to chemists in different parts of the world. The returns were rather incomplete, only seven chemists outside of the laboratory in Berlin having reported results. The results as far as reported show quite a remarkable agreement, in general, in the values obtained. In some instances, however, considerable variations were noted. The chairman stated that the work would be continued during the coming two years with more care, and, if possible, with a greater number of chemists. He urged all those who received the plates for trial to complete their trials as soon as possible, so that the plates might be forwarded to the next person. In this way a great deal of time could be saved. The importance of temperature in the observations was referred to, especially in the light of the paper read by Dr. Wiley before the congress, showing the great variations in polarization in quartz plates in sugar solutions produced by variations in temperature. The importance of securing quartz plates in some way so that changes of temperature would not subject them to pressure, was fully discussed. Dr. Wiley called attention to the fact that the quartz wedges in compensating instruments were subject to the same influences, and therefore that they should be mounted in the same way as the quartz plates to avoid pressure by changes of temperature.

A general agreement was made to the proposition to substitute for all the different flasks in use a true decimal flask holding exactly 100 cc. To avoid expensive changes in polariscopes already in use, it was decided advisable to change normal weights of sugar employed in polarization to correspond to the flask. For the ordinary instruments, in which the normal weight for the Mohr flask is 26.048, the normal weight for the true flask is almost exactly twenty-six grams. For industrial purposes it was decided that it was not advisable to practice the inversion method of polarization with raw sugars. The slight errors which are introduced into polarization by the invert sugar are partly compensated for by the volume of the lead precipitate. As quickness of work is important in commercial operations, the introduction of the inversion method would be more objectionable than the slight errors which result from the single polarization. The use of animal charcoal for clarifying sugar solutions

was condemned on general principles, on account of its high absorptive power for sugar.

The importance of introducing uniform methods of examination in all countries was unanimously acknowledged, but it was also stated that an attempt of this kind would be attended with serious obstacles and could only be accomplished gradually. It was voted that the chairman, with the aid of the members of the commission, prepare a comprehensive review of the analytical methods used in various countries, as well as of the regulations which are followed in checking disagreeing analyses. This compilation of methods is to be used by the committee in a final report on a uniform international method of working.

Excursions and Scientific Visits.

Numerous excursions to points of general and scientific interest were offered to the congressists.

IMPERIAL JUBILEE EXPOSITION.

Special entrance cards at a reduced rate were offered to members to visit the Imperial Jubilee Exposition located in the Prater. This exposition is held in honor of the fiftieth year of the reign of the Emperor Francis Joseph I. The buildings are situated in a pleasant part of the Prater, and are well placed and built with fine architectural effect. The exposition itself possesses the salient features of modern affairs. During the day, and especially in the evening, excellent bands and orchestras provide delightful music, which is given under cover in inclement weather. The formal visit of the congress to this exposition took place on Sunday afternoon, July 31st.

EXHIBITION OF ALCHEMIC MEDALS, ETC.

The most interesting collection of objects relating to alchemy was opened to the congressists free of charge on Wednesday, July 27th, and Saturday, July 30th. This collection is the property of the Imperial family, and was kindly lent by the Emperor especially for the entertainment of the members of the congress. That Vienna was one of the centers of alchemy, was shown by the address of Prof. Bauer.

EXCURSION TO KAHLENBERG.

On the afternoon of Friday, July 29th, the excursion to Kahlenberg took place. From this renowned overlook hill the city of Vienna may be seen in all its beauty. In the words of the late Crown Prince Rudolf, " This Imperial capital city, with its magnificent buildings, the old Stephan's Dom, index of centuries of greatness, in their center, situated on the majestic Danube, surrounded with a wreath of attractive mountains,

vine-clad hills, and waving forests, so beautiful, so rich in past honors, and still so young and blooming, is a picture such as no other metropolis in the world can present."

On the plateau of the Kahlenberg Hotel a dainty luncheon was served, enlivened by a well-trained quartette of Old Vienna singers. Unfortunately a thunder storm coming on later in the evening brought to a hurried close an otherwise most delightful occasion.

VISIT TO THE WINE CELLARS IN KLOSTERNEUBERG.

By invitation of Prof. Dr. Roessler, the congressists had an opportunity to visit the celebrated Stifftkellers in Klosterneuberg on July 30th. After spending the afternoon in studying the various processes of wine manufacture and visiting the cellars, the members were entertained with " eine gessellige Zusammenkunft im Stifftshank," which was most thoroughly enjoyed.

VISIT TO THE GAS WORKS.

After the formal visit to the exposition on Sunday, those members who desired to go were driven to the city gas works in Bezirk Semmering, where the methods of supplying the city with gas were explained in detail.

VISIT TO THE SEED CONTROL STATION.

Members interested in testing the purity and vitality of seeds were given an opportunity to visit the Agricultural-botanical Experiment Station on Monday, August 1st. The director of the station, Dr. Weinzierl, conducted the visitors through the various laboratories, and explained the methods of determining the purity and vitality of seeds.

VISIT TO THE IMPERIAL OPERA HOUSE.

All delegates from foreign countries were invited to occupy stalls at the Imperial Opera House on the evening of August 2nd. The representation of " The Bride of Corea," a grand ballet with numerous tableaus descriptive of Corean life, was given with an artistic perfection which exacted the greatest enthusiasm. The Americans especially enjoyed the tableaus of the great naval fight between the Chinese and Japanese, which were given with great effect.

EXCURSION TO SEMMERING.

The official excursions connected with the congress were brought to a close on Wednesday, August 3rd, by a visit to the Austrian Vorderalpen at Semmering. The distance of the Semmering from Vienna is about seventy miles, and the trip was made through a most pleasing valley and over a gentle, but

continuous, acclivity. The altitude of the hotel which overlooks the collection of mountains and valleys constituting the Semmering is 1,200 meters. A clear sky and medium temperature served to make the day more agreeable and the views more distinct. From the hotel the Schneeberg, which is the source of the Vienna water supply, is plainly seen. The melting snow, which is the source of the water supply in summer, insures to Vienna an inexhaustible supply of cold, clear, and pure water, quite in contrast with that supplied to many other European cities. After spending the day in strolling over the shady paths and sitting in the shade, and admiring the landscape in ever-changing lights, the congressists assembled at 5 P.M. on the terrace of the hotel for a final banquet. After the dinner was served, a number of farewell addresses was made. The American delegate, in thanking the organizing committee for the many courtesies which he and his colleagues had received, expressed the hope that at no distant day an opportunity might be given to American chemists to reciprocate the favors which they had enjoyed. He feared that a summer meeting of the congress in Washington would not develop a need for overcoats, but ventured to prophesy that the reception which foreigners would receive would be at least as warm as the weather. He would undertake to at least ask the Secretary of the Navy to supply a magnificent transport to convey foreign delegates across the water, where the cementation of international friendship would be made stronger. Chemistry, which had made war so destructive, was destined, in the end, to secure universal peace and good will.

Banquets and Receptions.

In addition to the excursions and visits which have already been described, a number of luncheons, banquets, and receptions were offered either to all or to certain groups of members. The most elegant and numerously attended of these was given by the Burgomaster of Vienna, Dr. Lueger, at the Rathhaus, on Friday, July 29th, from 12 to 2 P.M. At the opening session of the congress, Dr. Lueger gave the following cordial invitation to the congress to accept the official hospitality of the city of Vienna:

"Permit me, honored sirs, as mayor of the City of Vienna, to extend to you a most cordial greeting. Permit me, first of all, to thank you for having Vienna as the place of your meeting. The commonwealth of Vienna will follow your deliberations and conclusions with the greatest attentiveness. Chemistry has become necessary to every step of public life. If we want to know whether water is good or not, we must ask the chemist. If we want to know whether what is bought as human food is

wholesome or not, we must ask the chemist. When we wish to know whether a given soil is fit for this or that purpose, we must ask the chemist. Therefore it is of the highest advantage to us that these gentlemen who devote their studies to applied chemistry have chosen to meet here. You will now permit me to repeat orally the already published invitation from the Common Council and Aldermen of Vienna to visit the City Hall to-morrow to break off for an hour or two from your scientific duties, in order to enjoy a lively reunion. Such interruptions of scientific efforts, as each one knows, serve to strengthen the mind in a most marked manner, and are absolutely necessary to reach happy and successful conclusions. I hope that to-morrow I shall be permitted to welcome all the chemists of the whole earth at the City Hall. It is understood that I also will greet with great pleasure the chemists of the gentler sex. Allow me to close with the wish that the results attained by you shall meet with full and complete success, and that, contended with the end of your labors, you may have a happy return to your homes. Again, in the name of the city of Vienna, I greet you."

At noon the members of the congress assembled in the reception room of the Rathhaus, and for once the "chemists of the gentler sex" attended in great numbers. An hour was spent in visiting the paintings and collections in the various halls of the building. The members and their women friends then gathered in the dining-room, where they were again cordially welcomed by Dr. Lueger, and proceeded to act on his suggestion to hold a "lively meeting." Most convincing proofs were forthcoming to show that the Burgomaster had indulged in no empty phrases in extending the city's hospitality. So lively had the meeting become that it was with great difficulty that the postprandial orators could make themselves heard. At the close of the banquet the members assembled in front of the Rathhaus, and a photograph of the party was made.

DINNER GIVEN TO THE FRENCH GROUP.

On Friday evening, July 29th, Mr. Maurice Deutsch gave a dinner in Sacher's Garden to the French members, to which your delegate had the honor of being invited. The elegant dining-room of this famous restaurant was beautifully decorated, and a dinner of the highest artistic and gastronomic perfection was served. After-dinner addresses were made by Messrs. Deutsch, Moissan, and Wiley. Sixty guests enjoyed Mr. Deutsch's cordial hospitality.

DINNER GIVEN TO THE INTERNATIONAL COMMITTEE ON THE UNIFICATION OF METHODS OF SUGAR ANALYSIS.

The Austrian Society of Beet-sugar Industry gave a dinner at

the Hotel Bristol, on Monday, August 1st, to the members of the International Committee on the Unification of Methods of Sugar Analysis. Thirty guests were present. Dr. Herzfeld, the president of the committee, occupied the seat of honor at the right of Director Ströhmer, who presided at the dinner. After the coffee was brought on, Dr. Herzfeld spoke of the work already done by the committee, and of the aims it had in view. The discussion was continued at great length by other members, and the meeting adjourned at midnight with a sense of having accomplished a great deal of good work in conjunction with a most delightful social occasion.

OFFICIAL BANQUET.

The banquet given by the congress to the delegates from foreign countries was held on Sunday evening, July 31st, in the restaurant in the Volksgarten. It was at first intended to have the tables in the open garden, but the weather having become very cold compelled the removal of the tables, at the last moment, to the circular dining-hall surrounding the court of the restaurant. The presiding officer was the minister of commerce, the president of honor and the acting president sitting at his right and left. The vice-presidents and delegates from foreign countries sat to the right and left of the two presidents. The banquet was followed by after-dinner speeches by the presiding officers and delegates from foreign countries.

Chemical Laboratories in Vienna.

All the chemical laboratories of Vienna were thrown open to the congressists, but no formal visits were made thereto. The members, singly or in groups, visited the laboratories at such hours as proved to be the most convenient.

THE UNIVERSITY LABORATORIES.

There are three distinct chemical laboratories connected with the university. The first laboratory occupies the most of the parterre of the Chemical Institute, No. 10 Währingerstrasse. It contains working desks for seventy students and for twenty-one advanced students and assistants. The professors and assistant professors occupy six smaller halls. There are two balance rooms, but only thirteen balances for all the students. The number of students received is limited to the desks available, and consists of those students of the university who are candidates for degrees in pharmacy or philosophy. The number of papers, theses, etc., which have been published from the laboratory is 285. The director of the laboratory from its foundation to 1876 was Hofrath Prof. Dr. Franz Karl von Schneider, from 1876 to 1890 Hofrath Prof. Dr. Ludwig Barth von Barthenau, and the present director is Prof. Dr. Hugo Weidel.

The second university laboratory occupies the whole of the first story of the Chemical Institute, and contains two large working rooms for beginners and seventy desks for advanced students. There is also a large number of small laboratories for the use of the professors and assistants. As is the case with the first laboratory, it contains a small library, where the leading chemical journals and works of reference may be found. From this laboratory, since 1876, 292 original papers have been published. The present director is Hofrath Prof. Dr. Adolf Lieben.

The third laboratory connected with the university is situated at No. 1 University Place. It is devoted especially to analytical chemistry, and four preparative rooms for the experimental lectures. The director of this laboratory is Prof. Dr. Eduard von Lippmann.

The laboratory for medical chemistry is also a part of the university system under the Pathological Institute and is devoted especially to practical medical studies. It is situated in the general hospital building in Spitalgasse. It is provided with 48 working desks, and 10 for advanced students. In addition to these are found the laboratories for the professors and assistants. The number of the students is limited, and consists exclusively of those who are candidated for the degree of doctor of medicine. The papers of the laboratory are published partly in medical and partly in chemical journals. The director of the laboratory is Hofrath Prof. Dr. Ernst Ludwig.

LABORATORIES OF THE TECHNICAL HIGH SCHOOL.

The Austrian Technical High School corresponds to our Institute of Technology, and the one at Vienna is justly celebrated. There are five laboratories connected with this school.

1. The laboratory for general chemistry consists of six rooms in the parterre of the school building. The teachers and advanced students of this laboratory are occupied with researches of a scientific and technical nature. The director of this laboratory is Hofrath Prof. Dr. A. Bauer.

2. The first laboratory for chemical technology of organic bodies is located on the court of the school building, and consists of two separate halls. The first has desks for twenty students, balance rooms, preparation rooms, etc. The second has the same number of students' desks, but is used for the advanced students and for research. The director of this laboratory is Prof. Dr. Hugo Ritter von Perger.

3. The second laboratory for chemical technology of organic materials is one of the largest belonging to the high school. It occupies thirteen rooms in the middle area of the building. Students of the third year's course are received in this laboratory, and also officers of the technical troops (engineers, sappers,

and miners). The students are occupied chiefly with studies in organic chemistry. The director of this laboratory is Prof. Johann Oser.

4. The laboratory for analytical chemistry embraces eleven rooms on the first story of the school building, and has desks for 118 students. The director of this laboratory is Prof. Dr. G. Vortmann.

5. The laboratory for fermentation and bacteriology is the latest addition to the chemical equipment of the high school. It was founded in 1897, and during its first year enrolled twenty-seven students, of whom two were foreigners. It is equipped with all the latest apparatus for studying the phenomena of fermentation and bacterial activity. The director of this laboratory is Dr. Lafar.

LABORATORIES OF THE IMPERIAL HIGH SCHOOL FOR AGRICULTURE.

There are two laboratories connected with this institute :

1. The laboratory for field and forest chemical technology was opened in 1872. It consists of a chemical and fermentation-physiological department, the latter having just been established. The chemical laboratory embraces two large halls, each arranged for sixteen students. In addition, there are balance rooms, photographic ateliers, and separate laboratory rooms for the professors and assistants. There are also a large lecture-room and a special room for microscopic research, storerooms, etc. Only students of the School of Agriculture are received in this laboratory who have had at least three semesters in the laboratory for general chemistry. The program of studies embraces researches in the chemistry of sugar, starch, malt, beer, and alcohol manufactures, as well as in wine-making. The course lasts for two semesters. The director is Hofrath Prof. Dr. Schwackhöfer.

2. The laboratory for general and agricultural chemistry embraces a suite of fourteen rooms, desks for ninety-eight students, laboratories for professors and assistants, and all modern appliances for chemical agricultural studies. The director is Prof. Dr. G. Zeissel.

CHEMICAL LABORATORY OF THE GEOLOGICAL SURVEY.

This is one of the oldest laboratories in Vienna, having been established in 1849, "for the purpose of studying all kinds of soils and rocks, ores and fossils; also the different products of the mines of the Empire." A long series of publications on the chemical composition of rocks and minerals, mineral waters, and on crystals and crystal formations, has issued from this laboratory and been published chiefly in "Verhandlungen der k.k. geolog. Reichsanstalt," or in the "Jahrbuch der k.k. geolog. Reichsanstalt."

The laboratory was at first under the direction of Dr. F. Ragskys, and after him came Dr. Karl von Hauer. At first the chemists in this laboratory had no official standing, and only in 1872 were they recognized as of equal rank with the geologists. Baron Heinrich v. Foull, the late director of the institute, was slain by the natives of the Solomon Islands during a visit there in 1896. The present director is Dr. Konrad v. John, who has numerous assistants, most of them volunteers.

CHEMICAL LABORATORY OF THE TECHNICAL MILITARY COMMITTEE.

In this laboratory the government investigations of explosives are conducted. Also all the materials, such as clothing and food, which are furnished to the army and navy, are examined in this laboratory.

CHEMICAL LABORATORY OF THE MILITARY SANITARY COMMITTEE.

This laboratory was founded in 1854, and has, for its chief purpose, the examination of drugs and medicines, and medicinal supplies furnished to the army and navy. The director is Dr. Florian Kratschquer.

IMPERIAL GENERAL RESEARCH INSTITUTE FOR FOODS.

This is one of the latest foundations of the governmental scientific institutions, having been opened on the 1st of December, 1897. It is charged with the official inspection of the trade in all kinds of foods and drinks consumed by man. In addition to its official duties, this institute is authorized to make examinations of foods and drinks for private persons on the payment of fixed fees. This work, however, may be refused if it conflict with official duties. The chemists employed here must have diplomas showing that they are food experts. The scientific staff of the institute is also charged by law to make researches in respect of the composition and properties of human foods and the best methods of studying them. The director of the institute is Dr. Max Grueber, professor of hygiene in the Vienna University.

CHEMICAL LABORATORY OF THE GENERAL POLYCLINIC.

The studies of this laboratory are directed mainly to pathological products, serums and other products of biological activity, with special reference to diagnosis and therapeutics. It has roomy and well-illuminated quarters, and is under the direction of Dr. Julius Moultner, university professor of applied medical chemistry.

THE IMPERIAL AGRICULTURAL CHEMICAL EXPERIMENT STATION.

This institution is the head of all the agricultural experiment stations of the Austro-Hungarian monarchy. It was established in 1870, and now is located in commodious quarters at No. 3, Trunnerstrasse, in the Second Bezirk. The first director of the station was Dr. Ignatius Ritter von Moser. From his death until the spring of 1898 the station was under the direction of Prof. Dr. Meissl. In the spring of that year Dr. Meissl was made emeritus professor and transferred as advisor and technical assistant to the ministry of agriculture. Prof. Dr. Dafert has just been called to the directorship of the station, with Prof. Joh. F. Wolfbauer as his first assistant. This laboratory is charged with the general direction of all the great problems underlying agricultural progress; *viz.*, researches in animal and plant production, acclimatization of plants and animals, fertilizer control and analysis, making chemical, microscopical, and physiological investigations for the minister of agriculture, and, under certain conditions, for private citizens. The station is also charged with giving advice and instruction on agricultural subjects, and with training of agricultural experts. In general, this station holds the same relation to the minister of agriculture that the Divisions of Botany, Vegetable Pathology, Soils, Biochemistry, and Chemistry hold to the secretary of agriculture, in Washington. In connection with the station a vegetation house has been established at Kornenburg for practical demonstrations in plant nutrition and physiology, similar in every respect to the vegetation house of the Division of Chemistry, at Washington. The feeding experiments are conducted in a large respiration apparatus, built, in general, according to the Pettenkofer plan. Extensive experiments of a chemical-physiological nature are made with calves, cows, sheep, pigs, and even horses. This institute claims the credit of being the first to demonstrate beyond question that the carbohydrates are the chief source of all the fat of the animal organism. Among some of the subjects more recently investigated in this laboratory may be mentioned the composition and value of the different foods of the Austro-Hungarian monarchy, the proteid and fatty bodies in beans of soja hispida; the cause of the superior nutritive properties of Alpine hay; the composition of the flesh of whole animals fed under different systems of nutrition; the critical examination of the methods of analysis of the different organs of the body and their secretions; the influence of fertilization; the composition of field and garden plants; and the chemical and physical properties of peaty soils. Important dairy researches have also recently been made, especially in respect of the preparation and preservation of strong extracts of

rennet on the condensation and preservation of milk, and on the testing of milk and milk products for purity and adulterations. Extensive studies have also been undertaken on the properties and methods of estimation of the most important sugars as related to the theory and practice of fermentation. In connection with this study valuable contributions on the subject of the relative fermenting power of yeasts have been conducted. A study of the composition of the water of the Danube at Vienna for every day in the year has also lately been made.

In addition to this public work the institute is also authorized to undertake private analyses at a fixed price, the fees so obtained becoming a part of the available funds of the laboratory. The number of these analyses, which in 1877 reached scarcely 1,000, amounted in 1896 to 14,940. To your delegate this laboratory was naturally the most interesting of all those visited, and he is indebted to Director Dafert for many courtesies attending his visit. This chemical experiment station shows, in a most convincing manner, the fundamental position occupied by chemistry in almost every problem connected with agricultural research. In Europe, more than in America, is this relation recognized, and there is scarcely a single station of the 100 existing in Europe which does not have a chemist for a director. In fact it is doubtful whether any agricultural station in which the chemical idea is not dominant can ever reach the full measure of its usefulness, or study intelligently and successfully any of the really great problems connected with agricultural research. Of how little relative value the non-chemical researches are which are connected with agriculture may be readily seen by consulting the personnel of the European stations. This fact is mentioned with no purpose of discrediting the work of entomologists, botanists, and other scientists in relation to agricultural development, but only to recall to the thinking public the very foundation of agricultural science, which relates first of all to the productivity of the soil. The fertility of the fields is the first great need of agriculture. After that come the development of domestic animals, the study of their diseases, and the study of the adaptability of plants and the habits of useful and injurious insects.

PHOTOCHEMIC LABORATORY.

The chemistry of printing with light is studied in a laboratory connected with the Imperial Graphic Teaching and Experiment Station founded in the year 1888. This laboratory consists, first, of a section for teaching the theory of photography and graphic reproduction; second, of a section for teaching the theory and practice of illustrating books and periodicals; third, an experiment station for photochemistry and photo-printing;

fourth, a museum containing collections illustrating all the subjects of study and apparatus for producing them. The director of the institute is Regierungsrath Prof. Dr. Josef Maria Eder, professor in the Technical High School. The staff consists of five professors, four special teachers, two assistant teachers, one privat docent, and numerous helpers.

CHEMICAL LABORATORY OF THE ART SCHOOL OF THE IMPERIAL MUSEUM FOR ART AND INDUSTRY.

The laboratory was established in 1877 for the study of glass, porcelain, and enamels. In 1888 it was transferred to the ministry of religion and education, and enlarged to embrace all subjects of artistic manufacture. Instruction and practice are given on the materials, means, and methods of artistic work. The chief subjects of study, however, remain those for the investigation of which the institution was originally founded. The director of the laboratory is Prof. Dr. Friedrich Linke.

TECHNICAL-CHEMICAL LABORATORY FOR THE LEATHER INDUSTRY.

The object of this laboratory is the promotion of the leather industry by scientific researches. The technical part of the work has for its object the conversion, into practical use, of the purely scientific studies. The laboratory was opened in 1874 by the minister of commerce. It contains a physical, a chemical, and a bacteriological laboratory, and a large special library of all principal works relating to leather, its preparation and uses. In 1882 the institute was transferred to the ministry of education. Since then a special course in instruction in the theory and practice of leather production has been organized for advanced students and technical workers. The director of the institute is Regierungsrath Prof. Dr. Wilhelm Eitner.

CHEMICAL-TECHNICAL EXPERIMENT STATION OF THE CENTRAL SOCIETY FOR SUGAR INDUSTRY.

Next to the agricultural chemical experiment station, this laboratory had the greatest interest for your delegate, and it was the only one to which he had time to make a second visit. It is under the direction of Prof. Dr. Friedrich Strohmer, the genial general secretary of the congress, assisted most ably by Dr. Anton Stift, one of the recording secretaries. Unfortunately for the chemical visitors, the laboratory was somewhat torn out preparatory to moving to the more commodious quarters which it will soon occupy at No. 18 Elizabethstrasse, Bezirk 1. The laboratory was founded, in 1859, by the Union for Beet-sugar Industry of the Austrian Empire. In 1867 the laboratory was transferred to Prag, at that time the center of the beet industry

in Austria. In 1869 it was moved to Gross-Seelowitz, the seat of some of the most important sugar factories of the Empire. One year thereafter the station was removed to Vienna, where it has remained ever since, and where it is now permanently located. The station is entirely independent of governmental control or assistance, and is the property of the Central-Verein für Rübenzucker-Industrie. Its purpose is the investigation of all subjects connected with beet-sugar production, whether of an agricultural, chemical, or technical character. The station also edits the journal of the society, the *Wochenschrift des Central-Vereins für Rübenzucker-Industrie* in den Oesterr.-Ungar. Monarchie. Private analyses for sugar growers and others are also made by the station at a fixed tariff, the fees derived therefrom becoming a part of the funds to sustain the station. From 1870 to 1898 there were made at the station 99,036 analyses, involving 223,120 quantitative determinations. The laboratory undertakes also to set standard solutions for the use of technical chemists in the various sugar factories, to adjust polariscopes and graduate flasks. Special botanists, entomologists, and pathologists are also employed for the study of beets, beet diseases, and injurious insects and molds. In the new quarters, to which the laboratory is about to be moved, greatly increased facilities for work will be provided, and under the able direction of Dr. Strohmer the station may be expected to accomplish even greater works than in the past.

CHEMICAL LABORATORY OF THE GENERAL AUSTRIAN DRUGGISTS' UNION.

This laboratory was founded in 1865, and has, for its chief object, teaching the theory and practice of pharmacy. A specialty is made of urine analysis for diagnostic and therapeutic purposes. The director of the laboratory is Dr. C. Glücksmann.

RESEARCH INSTITUTE OF THE GENERAL AUSTRIAN DRUGGISTS' UNION FOR FOODS, CONDIMENTS, AND DRINKS.

This laboratory was founded in 1888 in honor of the fortieth year of the reign of the Emperor. Its chief purpose is the analysis of all kinds of foods, condiments, and drinks for associations and private individuals, at a charge varying in amount with the magnitude of the work. It also gives instruction to graduates in pharmacy who wish to prepare themselves especially for food and drug analysis. A special course of lectures is given on food adulteration. The director of the laboratory is Dr. Moriz Mansfeld.

AUSTRIAN EXPERIMENT STATION AND ACADEMY FOR THE BREWING INDUSTRY.

This institute possesses one of the best appointed and most

complete laboratories for its purpose of any in Vienna. It was founded in 1887, but the Academy of Instruction was first opened in 1895. The laboratories of chemistry, fermentation, bacteriology, and botany are not only roomy and admirably equipped, but united in an organic union highly conducive to the best results. Each worker is not engaged alone in pushing his own researches, neglecting and even despising the work of others, but all in perfect harmony and under a single direction, are working together for one great purpose; namely, the placing of the brewing industry on a strictly scientific basis and promoting its progress by research and experiment. The course of instruction lasts for four semesters, and an entrance examination equivalent to that required for the voluntary one year military service is exacted. Foreigners also, who desire to pursue the course of study, must bring evidence of a suitable education. An experimental malt factory and brewery are connected with the station, where the results of all researches are subjected to practical demonstration. The director of the institute is k. k. Hofrath Fr. Schwackhöfer. The chief of the chemical laboratory is Dr. Ed. Jalowetz, and of the ferment-physiological laboratory, Dr. H. Wichmann.

CHEMICAL LABORATORY OF THE K. K. TECHNOLOGICAL TEXTILE MUSEUMS.

The object of this laboratory is to give theoretical and practical instruction to students proposing to enter the textile fabrics industry. It is one of the largest institutions of instruction in the world, and the annual expenditures of the institute amount to about 265,000 gulden. Since its foundation in 1881 more than 10,000 students have taken the course of instruction. The laboratory and school of instruction are under the direction of Dr. Paul Friedlander, who is assisted by a large corps of professors and specialists. The chemistry of dyeing is, of course, the chief subject taught.

CHEMICAL-PHYSIOLOGICAL EXPERIMENT STATION FOR WINE AND FRUIT CULTURE AT KLOSTERNEUBERG.

The instructive and agreeable excursion to this locality has already been referred to. Towards the end of 1870 this important station was founded by the k. k. minister of agriculture, and Prof. Dr. L. Roessler, at that time professor in the Technical High School at Karlsruhe, was appointed director. The charter of the institute required the most thorough scientific research into all the problems connected with wine-making and fruit culture. The work in general is directed

(*a*) To a chemical, microscopical, and bacteriological study of must and wine, of yeasts and the by-products of fermentation,

to studies of cellar fermentation and ripening, clarification, sucration, etc.

(*b*) To the chemical and mechanical analysis of vineyard soils.

(*c*) To the chemical studies of vineyard fertilizers and their effects upon the vintage.

(*d*) To the chemical and microscopical studies of the vine and fruit trees, with special reference to their constitution and ability to resist the ravages of diseases and insect pests.

The institution was also charged on its foundation with the publication of the results of its labors, and with furnishing advice and direction to those engaged in wine and fruit culture. The director of the station is Prof. Dr. Josef Leonhard Roessler, who showed many courtesies to the members of the congress who visited the station, both on the occasion of the general excursion and at other times.

The above brief review of the foundations for teaching chemistry and chemical practice in Vienna has been given as a proper adjunct to the special report of the congress, and because American chemists are not, as a rule, so well acquainted with the facilities for teaching chemistry in Vienna as they are with those in Germany and France. It is seen that there is no dearth of laboratories and experimental stations in the Austro-Hungarian capital, and the rulers of that eastern Empire are fully alive to the fact that only those nations which push chemical studies and apply them in a scientific technical manner can hope to keep abreast of the progress of the world.

These Congresses of Applied Chemistry teach, first of all, the fundamental relations of applied chemical research to all the great industries that make nations wise, rich, and powerful. The advance of any nation in wealth, civilization, and power is measured directly by the position occupied therein by chemical research applied to the arts and sciences.

And yet the makers of the wealth of nations, those who contribute most to its progress and welfare, who are most intimately related to all the industries of war and peace, strange to say, receive the least social and political distinction, and command the least compensation of all the classes who devote themselves to the public service and welfare. It is therefore suggested that a proper theme to receive the attention of the next congress, which meets in Paris in 1900, would be a "Report on the Fundamental Relations of Applied Chemistry to National Wealth and Progress."

H. W. WILEY.

NOTE.

A Convenient Method for Maintaining Reduction of Ferrous Solutions[1].—My reasons for calling attention to this method for maintaining reduction in ferrous solutions are, that it is economical, convenient, and effective, and so far as I have been able to ascertain, new, in this particular application.

Various methods have been used to keep ferrous solutions reduced, such as the introduction of zinc and sulphuric acid, and the addition of sirups, gums, sulphurous acid, or sulphuric acid. These are either unnecessarily expensive, or ineffective, as they may interfere with the uses of pure ferrous solutions, and I have not been able to obtain as satisfactory and permanent results with them, as with the method which I have made the subject of this note; namely, the addition of ten per cent. of concentrated sulphuric acid and a suitable amount of iron in the form of small wrought iron nails, to a ten per cent. solution of ferrous sulphate. The acid under these conditions liberates hydrogen very slowly, and yet fast enough to nullify the oxidizing action of the air, even when the solution is exposed in an open beaker.

I have found that ferrous solutions thus made up will keep for more than a month in a practically unchanged condition, while solutions made up with sirups, gums, or with free acids and similarly exposed, were very largely ferric at the end of the period, and acidified ferrous ammonium sulphate, $FeSO_4(NH_4)_2SO_4+6H_2O$, was in very little better condition.

When one requires a large amount of ferrous sulphate for qualitative classroom work, for example, an open beaker full of the reagent always in good condition, is very useful in saving time, and is of great convenience, and in these respects has been so satisfactory to me, that I venture to present the method to the members of the society. WILLIAM S. MYERS.

Rutgers College, June 3, 1898.

NEW BOOKS.

ELEMENTS OF GENERAL CHEMISTRY WITH EXPERIMENTS. By JOHN H. LONG, M.S., Sc.D. Chicago: E. H. Colegrove. 1898. Price, $2.00.

This is a compact text-book, filling only 408 pages, underta-

[1] Read before the New York Section, June 3, 1898.

king to give an introduction to the main principles of chemical science, an outline of the descriptive chemistry of the elements and their leading inorganic combinations, accompanied with directions for simple experiments by the student. In its preparation the author has used a part of his work "Experimental and Analytical Chemistry," now out of print, and has added new subject-matter, making it all anew as a text-book of elementary general chemistry, preparatory to the work of analysis.

Only the phenomena of physical and chemical change are presented in the introductory chapter; volume proportions are brought forward in the chapters upon oxygen, hydrogen, and chlorine, and it is not until following chapters that the atomic theory is broached, which is done with an excellent summary of its historical development. Still later on the subject of valence is presented, and some uses of structural formulas are set forth. Throughout the book the uses of equations and of constitutional formulas are quite carefully guarded against abuse, but as aids to study they are not by any means neglected.

In respect to solubilities the facts of saturation, precipitation, and crystallization are clearly distinguished in the very beginning of the book, but electrochemical theories of solution are not introduced at all.

The periodic system is brought forward when the metallic elements are taken up, together with further treatment of the subject of valence and of the determination of atomic weights. After this the periodic arrangement of the elements, well termed the *natural* arrangement, is observed through the remainder of the book.

In all the chemical descriptions, illustration is drawn from the relations of organic life and from the manufacturing arts, with justice to the present state of industrial chemistry.

The directions for experiments, distributed through the work, extend to 173 numbers. The author states that these experiments represent the work required in his classes during the past ten years' work, as it would appear, "repeated by the student in the laboratory" after like demonstration by the teacher in the classroom. Such exercises, following those of the lecture-table, undoubtedly serve, as the author says, to fix, as by repetition, the subject-matter of the lectures in the memory and mind of the

learner, with great advantage. But it may be doubted whether initiative exercises of this order will serve to develop the independent power of the student as well as a series of laboratory exercises planned expressly for the student, distinct from the order of the lecture course though on the same subject.

It remains to mention what is best about this book; namely, its personality, clearly recognized in every page by those who know the author and by those who have read his contributions. Personal qualities can be known more easily than named, but it can be said that the authorship of this little book is characterized by simplicity in description, directness in statement, breadth of view in science, caution in adoption of theory, care against misinterpretation, and experience with the applications of chemistry at the present time. A. B. PRESCOTT.

INTRODUCTION TO CHEMICAL-TECHNICAL ANALYSIS. By PROF. F. ULZER AND DR. A. FRAENKEL, Directors of the Testing Laboratory of the Royal Technological Museum in Vienna. Authorized translation, with an appendix by the translator, HERMAN FLECK, Nat. Sc.D., Instructor in Chemistry, University of Pennsylvania. Philadelphia: P. Blakiston's Son & Co. vii + 188 pp. Price, $1.25.

This book is apparently an effort to teach the student "something of everything" while the "everything of something" is left to the special treatise. Unfortunately the methods described under the different branches of technical work are generally very sketchy and few of them are capable of execution by the student without assistance.

The subjects treated include Products of Technical Chemistry, Cement and Clay, Metallurgical Industry, Alloys, Fertilizers, Sugar Industry, Fermentation Industries, Fats, Waxes and Mineral Oils, Mordants and Tanning Materials, Textile and Dyeing Industries, Products of the Coal-tar Industry, and in an appendix, White Lead, Manganese Dioxide, Bleaching Lime, etc., Asphalt and Food Stuffs.

The subjects most satisfactorily treated are the "Mordants and Tanning Materials" and the "Textile and Dyeing Industries." The one most unsatisfactorily treated is the "Metallurgical Industry."

The appearance and printing of the book is good and the index is well made, but the cross references in the body of the book

are far from satisfactory. For instance, on page 99, Kjeldahl's method is referred to as under "Nitrogen Fertilizers," page 78, whereas it is really under the head of "Nitrogen," page 74. On page 154 the chemical analysis of starch is referred to as being in Chapter VI, whereas it is really in Chapter VII, page 99.

Some proper names are misspelled, as Candlon for Candlot, page 39, and Brown for Drown, page 51.

ANDREW A. BLAIR.

COMMERCIAL ORGANIC ANALYSIS. By ALFRED H. ALLEN, F.I.C., F.C.S. Second edition. Vol. IV. Philadelphia: P. Blakiston's Son & Co. 1898. 8vo. 584 pp. Price, $4.50.

This work needs no introduction. The three earlier volumes—or rather five, for the third volume is really three in one—have gained a most enviable reputation, and have rendered more assistance than any other publication to those who have to do with proximate organic analysis. We have awaited this final volume of the work, therefore, with interest, and welcome its appearance most heartily.

The work is thoroughly up to date, including the most recent contributions to the literature of the field it covers. The author has evidently intended to give references to articles mentioned, and has usually done so, but unfortunately the reader is often referred to abstracts instead of original articles.

As stated in the preface, "Much of the matter of Volume IV is scarcely such as might be expected to be contained in a work purporting to treat of commercial analysis." This could not well be otherwise, for some of the subjects treated are among the most difficult to study and the least understood of all commercial products.

The subject-matter of the volume is arranged under the headings, "Proteids and Albuminous Principles," and "Proteoïds of Albuminoïds." The first 460 pages are of equal interest to the physiological chemist and the food chemist. Here are treated the proteids of eggs, blood, urine, and milk, as well as vegetable proteids, and methods are given for the examination of dairy products and of meat and meat products. The proteids of digestion, and methods for the examination of blood are also discussed at length.

The sixty-eight pages devoted to meat and meat products are especially worthy of note, though the apparatus described for the estimation of nitrogen (p. 32) would scarcely meet with the approval of our agricultural chemists.

The remainder of the volume is devoted to the proteoïds. The author has set for himself the very difficult task of classifying the bodies that come under this heading, and this treatment of them is probably as systematic as is possible with the knowledge we now possess of their properties.

The nomenclature of this subject is most bewildering, at present, so much so that it is necessary for a writer, in order to be understood, to give his interpretation of even the terms most commonly employed. Some writers, and even national associations, in trying to assist us, only add to our perplexity. We are glad to see, therefore, that the author of this work has striven, first of all, to promote uniformity, for instance, the term "albuminoïd" is used with the same significance as proteoïd, but it is suggested that, to prevent confusion, it be avoided whenever possible.

On the whole the volume compares favorably with the earlier volumes of the work, and cannot but do much to remove the difficulties that are encountered in the examination of nitrogenous compounds. W. D. BIGELOW.

MANUAL OF DETERMINATIVE MINERALOGY, WITH AN INTRODUCTION ON BLOWPIPE ANALYSIS. By GEORGE J. BRUSH. Revised by SAMUEL L. PENFIELD. Fifteenth edition. pp. 302. New York: John Wiley & Sons. 1898. Price, $4.00.

This book is so well known through its fourteen previous editions that it is surely superfluous for the reviewer to do anything more than to note the additions and changes which have been made, and to call attention to what appear to be defects or deficiencies.

The additions consist principally of a well-written and useful chapter on the physical properties of minerals, the greater part of which deals with crystallography, and, further, in the introduction into the tables of such well-defined mineral species as have been discovered in the twenty years since their last revision.

The most evident change has been in the reconstruction of the tables, with the dominant idea of making the chemical tests the

more decisive ones and physical tests principally subordinate. In doing this, the author has our most sincere approval; we felicitate him on the extent to which he has emphasized this change. When reviewing Dr. Frazer's tables for the determination of minerals by physical properties,[1] we felt constrained to remark that "every true scheme of determining minerals should start with and be based on their chemical composition, bringing in physical tests afterwards, etc.," and on this ground we condemned methods based on physical properties as "starting at the wrong end, and unfit to guide in the accurate determination of minerals in general." We therefore believe that Prof. Penfield has increased the accuracy and utility of his tables in proportion as he has brought the chemical tests forward as the primary ones and relegated the physical tests to their logical subordinate position. That he is thoroughly convinced of the desirableness of this tendency may be seen from the following extracts:

"It is believed that no methods are so generally to be relied upon for giving decisive results as those based upon the identification of the chemical constituents of the minerals."

"The tables have been so developed that tests for characteristic chemical constituents furnish the chief means for identification."

Our chief criticism of the method of the tables is that the author has not made these changes radical enough, that he still holds on to some physical tests as primary; whereas, to be consistent, he should have relegated them all to their proper subordinate position. The retention of luster and fusibility as primary divisions is the last relic of the former illogical and unsatisfactory method of classification, and it is to be regretted that the author did not perceive the desirability of retiring these from their too prominent function and thus coming at once to the logical simplicity of the chemical basis as primary.

It is in our judgment a defect of the book that many quick, decisive, and reliable blowpipe tests are not accounted at their proper value, and the recommendation usually given to make the corresponding wet test in their place. We think that the author undervalues the reliability of many flame and bead tests

[1] This Journal, 17, 353.

especially, which when carefully performed are really more decisive and satisfactory than the wet tests, besides being more quickly made and with simpler apparatus and reagents.

Another general defect is that the tables still fail to take account of some of the most common and practically inseparable impurities occurring in minerals. We cheerfully allow the truth of Prof. Penfield's remark that "it would be impossible to devise blowpipe methods to meet the contingencies arising from the various mixtures of minerals"—but does that excuse the classifier from taking into consideration the most frequently occurring isomorphous replacements which introduce foreign elements into the mineral?

To particularize: On page 246 are given the fusible minerals with metallic luster containing arsenic. The second mineral mentioned is characterized as containing both arsenic and antimony, leaving it to be implied that the thirty minerals following are free from antimony, and it is true that no antimony appears in their formulas. But it is nevertheless the fact that eleven of these thirty do often contain antimony, in amounts varying from four and eight-tenths to twenty-eight per cent., and that therefore any one of these eleven might, at times, give the reaction ascribed only to allemontite. Once again, on page 249, are given antimony compounds with lead, combined with first copper, then bismuth, silver, tin, and finally without any of these four elements. Yet, among the ten minerals in the last class, the simple fact is that six of them do at times contain enough copper (one to six per cent.) to give the reaction which would place them with bournonite, in the first class. These are only two instances of what could be illustrated in almost every division of the classification.

The question at once arises—Is an omission to take such cases into the account unavoidable? Would it be an impossible task to catalogue each mineral in every class into which its occasionally occurring inseparable impurities would unavoidably cause it to fall in practice? If that is in reality impossible, then we owe an apology to the author for dwelling on an unavoidable defect; for a defect it certainly is, since a mineral will, in general, fall into its correct place in the table only when it is the typically pure substance which the formula represents.

The adoption of the chemical basis of classification inevitably requires that variations of the composition of a mineral from the normal must be taken into account, when they affect its position in the classification. When such a classification, on the chemical basis, is *perfectly* carried out, then we will possess a theoretically perfect system of determinative mineralogy.

To sum up, then, this book is, in our judgment, the best treatise on determinative mineralogy that is yet published; but the tables have some defects of method and many deficiencies of detail, the correction of which would greatly increase their reliability. JOSEPH W. RICHARDS.

A TEXT-BOOK OF VOLUMETRIC ANALYSIS WITH SPECIAL REFERENCE TO THE VOLUMETRIC PROCESSES OF THE PHARMACOPOEIA OF THE UNITED STATES. BY HENRY W. SCHIMPF, PH.G., M.D., Professor of Inorganic Chemistry in the Brooklyn College of Pharmacy. Third edition, revised and enlarged. New York: John Wiley & Sons. 1898. xxx + 522 pp. Price, $2.50.

In its present form this work consists of four parts: Part I gives a description of the apparatus, indicators, methods of work and of calculation used in volumetric analysis, and also a concise statement of the methods to be used for the inorganic substances of the U. S. Pharmacopoeia. Part II is new and gives methods for the analysis of various medicinal acids and metallic salts. Part III is devoted to sanitary analysis and includes especially methods for the analysis of water, milk, butter, starch in cereals, diastasic value of malt, glycerin, alkaloids, vegetable drugs, and surgical dressings. Part IV gives gasometric methods for the analysis of carbonates, nitrous ether, nitrates, urea, and hydrogen dioxide.

The descriptions and directions are mostly clear and satisfactory, and the methods given are usually well suited for the purposes for which they are designed. Two or three matters of detail may be criticized: magnesium chloride is now generally used for magnesia mixture instead of magnesium sulphate, as recommended (p. 241). The standards for nitrites in potable waters (p. 313) do not agree with the opinion of the best authorities and should be revised. A table of atomic weights based on O = 15.96 is decidedly out of date, but that may be the fault of the pharmacopoeia rather than of the author.

Perhaps the most serious omission in the book is the failure to

give any rational discussion of the theory of indicators in acidimetry. Since Ostwald's discussion of the subject has become so easily accessible, any book on volumetric analysis which does not, at least, give an outline of the principles involved, must be considered as incomplete. W. A. NOYES.

COMMERCIAL ORGANIC ANALYSIS. VOL. I. BY ALFRED H. ALLEN, F.I.C., F.C.S. With revisions and addenda by the author and HENRY LEFFMANN, M.A., M.D. Third edition. Philadelphia: P. Blakiston's Son & Co. 8 vo. 557 pp. Price $4.50.

This new and thoroughly revised edition of Vol. I of Mr. Allen's valuable work will be heartily welcomed by chemists everywhere. The second edition was published in 1885, and the present volume had become a necessity in order that it might rank in completeness with the later volumes of the work.

The subject-matter has been brought well up to date by material furnished by both Mr. Allen and Dr. Leffmann. Numerous typographical errors in the second edition have been corrected and the index has been much improved by very considerable enlargement. The arrangement of the subject-matter remains essentially the same as in the second edition which was eminently satisfactory. The methods of the American Association of Official Agricultural Chemists have been included, very properly, in the text.

The following subjects have had much valuable matter added to them; *viz.*, Specific Gravity, Kjeldahl Process, Proteids of Wheat Flour, Vinegar, Brewing Sugars, Malt Substitutes, Hop Substitutes, Secondary Constituents in Spirits, Formaldehyde, Methyl Alcohol, Acetone, Fusel Oil, Argol, Starch, Glucose, Invert Sugar, Lactose, and Wine. The addenda treat of "Detection of Gallisin in Beer," "Invert Sugar," "Outline Process for the Detection of Bitter Principles in Beer," "Method for Estimating Galactan," and the "Determination of Pentosans by Means of Phloroglucol." WM. L. DUDLEY.

LEHRBUCH DER ANORGANISCHEN CHEMIE. VON PROF. DR. H. ERDMANN in Halle. Mit 276 abbildungen und vier farbigen Tafeln. Braunschweig: Friedrich Viewig und Sohn. 1898. xxvi + 756 pp. Price, *M.* 18.

The author states in his preface that he has taken as his model in the making up of this volume the well-known "Lehrbuch der Chemie" of Gorup-Besanez, and that he would have

called it the eighth edition of that work were it not that the changed condition of the science since its publication has rendered necessary a fundamental rearrangement of the subject-matter. The arrangement adopted is that usually followed in works of this character; *viz.*, (1) eighty-one pages of an "Introduction to Chemistry;" (2) "The Non-metals (Metalloide)" of 420 pages; and (3) "The Metals," 217 pages.

Under the first division, after a very brief explanation of the Roman and Arabic systems of numbers, and of logarithms, two pages each of a four-place table of logarithms and antilogarithms are given. Then follows a discussion of the fundamental principles of the science, such as "The Three States of Matter," "The Kinetic Theory of Gases," the "Nature of Chemical Changes," the "Atomic and Molecular Theory of the Composition of Matter," "Practical Methods of Determining Molecular Weights," the laws of "Combination of Gases by Volume," etc. The discussion of these principles is well done, and is more extended than is usually found in treatises the size of this.

The author says (p. 82): "By far the greater number of the chemical elements are solid, more or less easily fusible bodies of high luster, exceedingly opaque, good conductors of heat and electricity," etc. "These elements we call metals." As the chemist in classifying the elements for his purposes places no emphasis upon these purely physical properties, it would seem better were they classed as metals or non-metals in accordance with their base-forming or non-base-forming characteristics.

In the descriptive part of the book, the name of each element is followed by its molecular formula, its synonyms, and a list of its prominent physical and chemical properties. Then follows the occurrence of the element, its method of production, properties, and the properties of its inorganic compounds, and well illustrated directions for performing the most important laboratory experiments. Thirteen pages of text are devoted to helium and argon with illustrations of the apparatus for isolating them and examining their spectra, while a supplementary note on page 756 announces the discovery of crypton and neon. The structural formulas of many compounds are given, and molecular proportions are invariably expressed in chemical equations.

The "periodic law" is discussed in less than four pages near the end of the volume, and no mention is made in the descriptive part of the book of its aid in a rational system of classifying the elements. This neglect will appear to many chemists as a mistake of the author greatly to be regretted. Electrochemistry, the theory of solution, and ionization are also very briefly treated. The volume closes with a table of various distances, wave-lengths, etc.

The illustrations are numerous and excellent, and many of them are new to text-books of chemistry. The four lithographic charts of colored spectra are much superior to those usually published.

The work, taking it all in all, is an excellent one, and will be heartily welcomed by all who are interested in a wider diffusion of a knowledge of chemical science. W. W. DANIELLS.

PRELIMINARY REPORT OF AN INVESTIGATION OF RIVERS AND DEEP GROUND WATERS OF OHIO AS SOURCES OF PUBLIC WATER SUPPLIES. By the State Board of Health. 1897–1898.

Early in the report we find the very apt remark, that the examination of one or two samples of water taken from a stream, may give but little information as to its fitness for domestic use; and that, before deciding upon a proposed source for town supply, a much more comprehensive study, extending throughout the year, is imperative.

It is gratifying to note that "the Board has begun an investigation which it hopes to continue until the condition and liability of pollution of all important sources of public water supplies in Ohio, shall have been satisfactorily examined." Would that more states followed this excellent example!

The section, by Mr. Allen Hazen, devoted to "stream pollution," shows that most of the larger streams of the state are used for public supplies; that all of them receive a notable addition of sewage, and that the waters of such streams, below the sewage outfalls, are unwholesome.

Prof. N. W. Lord contributes a voluminous report upon the chemical examination of the waters of the Scioto, Olentangy, and Mahoning Rivers, which is followed by the bacteriological examination of the same waters by Prof. A. M. Bleile. Each of these investigators resorts to the graphic form to illustrate his

results, a mode of presentation that is always acceptable and striking.

Prof. Lord's methods of analysis do not vary from those usually followed, with the exception of a slight change in the scheme for "required oxygen." It is his custom to produce a faint pink color with the standard permanganate at the outset, and the amount of the reagent so used is not counted in the determination, it being considered to represent what is required to oxidize ferrous salts and hydrogen sulphide present. This suggestion would seem to be a good one, but the thought presents itself that easily decomposable organic matter might be present that would vie with the inorganic salts in rapidity of action.

Prof. Bleile very properly lays stress upon the fact that comparative results are looked for, in the bacteriological examination, rather than an exact knowledge of the number of germs present; and he very ingenuously makes use of a filter-paper saturated with formalin and placed within the cover of the Petri dish, in order to arrest growth after a fixed time, and prevent the colonies from breaking down the medium while waiting for their turn to be counted. He makes use of a beef-peptone-agar just alkaline to phenolphthalein, which is a reaction distinctly more alkaline than the medium commonly employed.

A report follows on stream gaugings and sources of river pollution, by Prof. C. W. Brown, after which Prof. Edward Orton, state geologist, devotes considerable space to "The Rock Waters and Flowing Wells of Ohio," chiefly of geological interest.

A "water-shed" map of the state closes a report of decided interest and value. There is no index. W. P. MASON.

BOOKS RECEIVED.

The Practical Compounding of Oils, Tallow, and Grease, for Lubrication, etc. By an expert oil refiner. London: Scott, Greenwood & Co.; and New York: D. Van Nostrand Co. 1898. vii+96 pp. Price, $3.50.

Ueber einen gasanalytischen Apparat. Von O. Binder. Reprinted from Chemischen Industrie, *1898*, No. 22. 12 pp.

Ginseng, Its Nature and Culture. Bulletin No. 78, Kentucky Agricultural Experiment Station of the State College of Kentucky, Lexington, Ky. November, 1898. 34 pp., with ten full-page plates.